The Modern Machinist

A PRACTICAL TREATISE ON MODERN MACHINE SHOP METHODS

Especially adapted to the use of Machinists, Apprentices, Designers, Engineers and Constructors

DESCRIBING IN A COMPREHENSIVE MANNER THE MOST APPROVED METHODS, PROCESSES AND APPLIANCES EMPLOYED AT THE PRESENT TIME FOR CUTTING, SHAPING, FITTING, ERECTING AND FINISHING METAL WORK, ON THE VISE, FLOOR, LATHE, PLANING, SHAPING, SLOTTING, MILLING, DRILLING, GRINDING, AND OTHER MACHINES, BEING WRITTEN IN A THOROUGHLY PRACTICAL UP-TO-DATE MANNER

By JOHN T. USHER

Fully illustrated by two hundred and fifty-seven entirely new and original engravings, being made expressly for this book

FIFTH EDITION

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PREFACE.

IT has become almost a custom in writing a treatise pertaining to "machine-shop practice" to devote a considerable portion of the contents to a description of the machine tools—and the cutting tools employed therewith.

On general principles it may be said that the improvements in the construction of machine tools for general machine-shop work have not been so "marked" as the improved methods of and appliances for handling the work thereon. Hence it is thought that the omission of the usual description of the ordinary machine tools and the cutting tools employed therewith will not be in any way detrimental, but that a more useful purpose will be served by endeavoring to omit as far as practicable anything that has heretofore appeared in print on this subject, describing and illustrating in the place thereof the means actually employed for performing the operations on various classes of work in many of the most prominent machine shops in this country and in England.

Modern machine-shop practice, according to the author's conception of the term, consists of the methods and means of doing work which are or can be employed in the majority of machine shops where the facilities consist not in "special" but in "ordinary" machine tools and appliances; therefore while we do not in the least underestimate the value, advantages and capabilities of "special machine tools," we have confined ourselves exclusively to the methods and appliances which are usually available or can be readily made in any ordinary machine shop, and which can be used on or in connection with the ordinary forms of machine tools.

Essentially in showing and describing the means employed for doing work of any kind, reference must at all times be made directly to the work under consideration. But it does not necessarily follow that the means and devices shown can only be employed for doing that particular piece of work. It is a matter of some difficulty to select in every instance such parts of work as will show the general utility of the methods and appliances employed for doing the work thereon to the best advantage; but great care has been exercised in choosing the work and parts thereof, to let it be such as is most familiar to the machinist in general practice, and such as will readily show the applicability of the methods and devices to a wider range of machine-shop work.

In making so many of the descriptive drawings in perspective instead of by the ordinary rules of projection, an innovation has been introduced which we believe has never been carried out on so large a scale before in a work

of this kind. This has naturally increased the cost and labor of compilation considerably, and it is hoped that the value of the book is proportionately enhanced thereby, inasmuch as a more intelligent and comprehensive idea of the subject is gained.

We wish to acknowledge with thanks the kind assistance rendered by many prominent firms and mechanics, in furnishing sketches of and permission to insert the devices employed by them in their own practice.

THE AUTHOR.

New York, 1895.

PREFACE TO THE FIFTH EDITION.

The gratifying success of the previous editions of this work has rendered necessary the printing of this, the Fifth Edition.

The publishers hope this edition may prove a valuable assistance to its readers and hereby wish to acknowledge thanks to the mechanical journals and others who have endorsed this work so highly.

THE PUBLISHERS.

New York, 1904.

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CHAPTER I.

Measuring Instruments.

In former times the only measuring instruments employed were the measuring bars, graduated rules (or scales), and graduated beam calipers. The latter being in all probability among the oldest measuring instruments with which we are acquainted; and the subsequent improvement of the same by the addition of the "Vernier" adjustment and its adaptation to inside measurements render this tool one of the most accurate and reliable tools which can be used for this purpose.

The evolution of the micrometer calipers and measuring machines was the greatest advance ever made towards the duplication and perfection in size of parts in machine construction.

It was some time after the micrometer calipers for outside measurements had been in general use before micrometer calipers for inside measurements were introduced, and it took a still longer time to place them successfully upon the market, as micrometer calipers for inside measuring purposes were not as favorably received as were those for outside measuring purposes.

As most, if not all, of the micrometer calipers for both outside and inside measurements have been profusely illustrated in the trade journals and in books and catalogues, and as they are in constant use in most workshops, we shall mention such only as have not been shown and described elsewhere.

INSIDE MICROMETER CALIPERS.

The inside micrometer caliper shown at Figures 1 and 2 was designed by the author for his own use several years ago, and subsequently patented but never placed on the market.

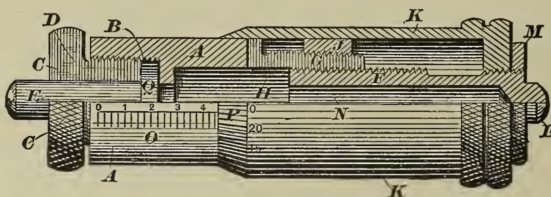


Fig. 1.

Figure 1 is a side elevation half longitudinal section of the instrument, and Figure 2 is a similar elevation of the same with longer (plain) tail-piece.

The instrument as shown in Figure 1 consists of a cylindrical body A, which is bored and threaded at B to receive the tail-piece E and the chuck screw C. The body A is also threaded on the inner end, on the outside at G, to receive the adjusting nut J (which is cylindrical and of the same diameter as the body A, thereby serving to steady the sleeve K), and on the inside at G′ to receive the measuring screw F. The body has on the inner end two radial cuts or slits H, to admit of adjustment for wear on the measuring screw F in an obvious manner by means of the adjusting screw J. The sleeve K is screwed onto the

measuring screw F, and held in a fixed relation with the measuring screw and terminals by means of the nut M, which arrangement permits of adjustment for wear on the measuring terminals. The chuck nut C has a radial cut or slit on one side, which serves to permit of the bore of the chuck to collapse somewhat when the screw is forced into the threaded bore B, thus forming, when used in connection with a plain

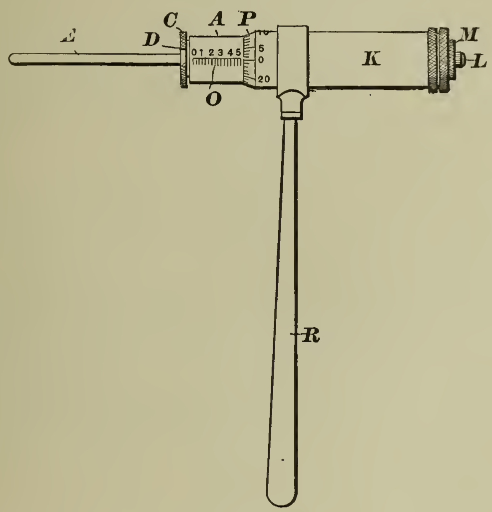


Fig. 2.

tail-piece E (Figure 2), a chuck. The bore of the chuck screw C is likewise extended through the shoulder of the body A, as shown near G (Figure 1), and nearly throughout the entire length of the measuring screw F, as shown at N. This permits of a plain tail-piece E (Figure 2) being used instead of a tail-piece E with the location collar on it, as shown at Q (Figure 1), when the instrument is to be used for other than

standard measurements. The graduations on the body A and the sleeve K are of the usual form.

In using the above instrument for standard measurements, the tail-pieces with collars on are used, the capacity of the instrument being increased or decreased by means of the measuring screw, and by the insertion of longer or shorter tail-pieces, as required. But when making shrinkage, tight or loose fits, where a stated allowance for the same is merely required, then the straight tail-piece may be used, the tail-piece being made to slide in or out to the size required and held by compression by merely tightening up the chuck screw C, the adjustment to correct size being made by the measuring screw.

ADJUSTABLE SNAP GAUGES FOR STANDARD MEASUREMENTS.

The absolute necessity of some arrangement for compensating for the wear of the various tools employed in machine-shop practice has engaged the attention of the machinists in all branches of the profession. In the case of taps and reamers, the necessity of some means of adjustment was seen many years ago, and was promptly met by the introduction of expanding taps and reamers, which filled the requirements of the case in every particular in a very satisfactory manner. We have adjustable mandrels (arbors), calipers, and other tools too numerous to mention; in fact, nearly every tool we use is adjustable in some way or other.

The standard snap gauges now so extensively used may very justly be said to be as far ahead of any and all other forms of measuring instruments for general use in the workshop for ensuring absolute uniformity and accuracy of machine parts as the micrometer caliper is ahead of the ordinary two-legged caliper.

But snap gauges appear to be an exception to the rule of supplying a means of adjustment for wear, no provision whatever being made for this purpose in general practice, or in any instrument now on the market, and consequently when such adjustment is necessary the gauge must in most cases be annealed

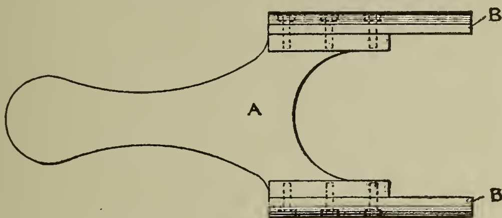


Fig. 3.

and closed or expanded and then rehardened and ground or lapped to size. Some years ago, Mr. A. D. Pentz introduced in his own practice (and subsequently described and illustrated in the "Iron Age") an adjustable snap gauge, which for simplicity and accuracy probably could not be improved upon.

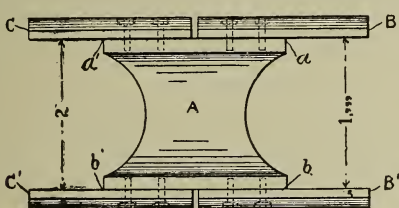


Fig. 4.

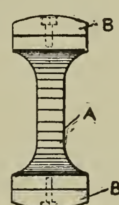


Fig. 5.

The construction of this gauge is shown in Figures 3, 4 and 5. Figure 3 is a side elevation of the gauge (single ended). Figure 4 is a side elevation of the gauge (double ended in this case, in the form of a limit gauge). Figure 5 is an end elevation of either or both of the above.

As shown in the figures, the gauge consists of a body A and two or four (for single or double gauge) pieces or measuring terminals B B′ and C C′, which are bolted to the parallel surfaces a a′ and b b′ of the body A by means of the counter sunk screws (plainly shown by the dotted lines).

The beauty of this form of gauge is that the surfaces a a′ and b b′ are made parallel with each other and of the same distance apart as the gauge is to be, thereby making it possible to always maintain or restore the standard of the gauge, for when the measuring surfaces have become worn beyond the allowable limit it is only necessary to remove the pieces B B′ or C C′ from the body A and grind or lap the surfaces a b or a′ b′ of these pieces until they are true again, and then replace them on the body A and the gauge is adjusted to standard.

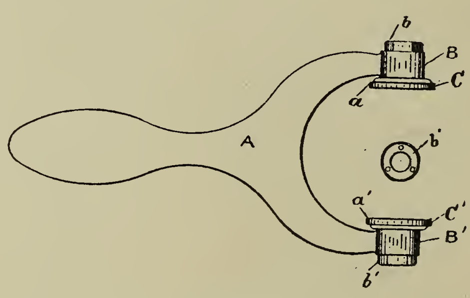


Fig. 6.

Figure 6 shows side elevation of an adjustable snap gauge which is easy to maintain at or restore to the given standard.

The arms of the body A (the body may be of any pattern desired) terminate in the form of hubs; these hubs B B′ are bored out parallel with each other and faced off on both ends of the hubs. The jaws C C′

which form the measuring terminals are turned and hardened and inserted in the hubs B B′. The flanges a a′ are made either round or square as preferred. As the jaws may be sprung somewhat in hardening, a slight allowance is made for grinding or lapping the gauge to size after they are inserted in the hubs. The collar nut b b′ b″ is made preferably round, with holes drilled therein for a pin or spanner wrench, to prevent any possibility of the gauge being tampered with. When it is necessary to adjust the gauge for wear, very thin metallic or paper washers are inserted between the flange C a and the hub B, and if necessary the gauge is relapped or ground to size. This instrument can be used for different sizes by inserting jaws of such thickness as to reduce the gauge to the size required.

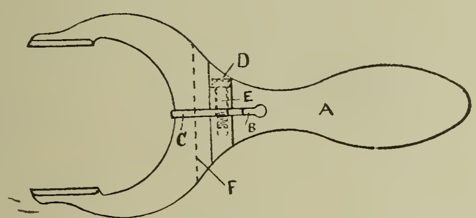


Fig. 7.

Another form of adjustable snap gauge is shown in Figure 7. The body A (which is of an ordinary pattern) is slotted at B to receive the distance piece or liner C, and drilled and tapped at D for the binding screw E. When the slot B has been cut the jaws are sprung apart somewhat to create a continual tendency to close together, and the liner C is fitted closely in the slot B, while the jaws are in this position, after which the liner is hardened and inserted in the slot and the binding screw tightened up. The jaws are then ground and lapped to size.

To adjust the gauge for wear the liner is taken out of the slot and reduced in thickness as much as required; it is then replaced, and, if necessary, the jaws are relapped to size.

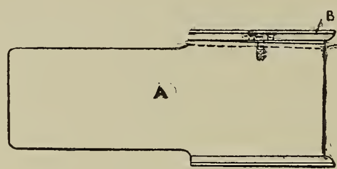


Fig. 8.

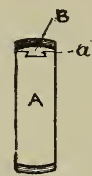


Fig. 9.

Figures 8 and 9 represent an adjustable snap gauge for internal measurements, Figure 8 showing a side and Figure 9 an end elevation of the instrument. The blade B is inserted in the body A in a dovetailed slot, the bottom of which is an inclined plane. When the instrument is worn below size it is only necessary to drive the blade B further into the slot, and by that means enlarge the diameter of the gauge as much as required.

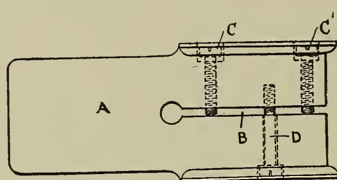


Fig. 10.

Figure 10 represents another form of adjustable snap gauge for internal use. A slot B is cut in the body A, two adjusting screws C C′ are inserted in the body on one side of the slot and a binding screw D on the opposite side. To adjust the gauge the screw D is loosened and the screws C C′ are tightened up until

the gauge is expanded as much as required. After expanding either of the above gauges they should, if necessary, be reground to size.

Whenever any change is made in an adjustable snap gauge it should always be made by the toolmaker, and the accuracy of the gauge should be tested after each change.

Any of the above types of snap gauges may be made in the form of double gauges and combined so as to form two gauges of different diameters, or to make one end for internal and the other end for external measurements. None of the foregoing adjustable snap gauges are patented and can, therefore, be made and used by any one desiring to do so.

Experience has shown that when a snap gauge is ground to size the measuring surfaces present a mass of minute prominences and depressions owing to the constant jarring or vibrating of the grinding machine or appliance, and that if, instead of grinding the gauges to size, a slight allowance is made for lapping them to size to remove all the above-mentioned prominences, the gauge will last much longer than if finished by grinding alone. In many instances where snap gauges for external measurements are supposed to be worn, it will be found that this effect has been produced by a process analogous to peening caused by pushing the gauge over or onto the work until the gauge strikes the work at some point of the inner circle or arch of the arms and body of the gauge with force sufficient to cause a slight bruise or indentation at that point, which, when often repeated, has a tendency to spread the arms apart and enlarge the diameter of the gauge, the same as though it had been peened.

This can readily be proven by filing all around the inner arch of the gauge, when on the tension being relieved; the gauge will spring back again to its

original diameter. The tendency to enlarge the diameter of outside snap gauges by this means can only be avoided by hardening the gauges to a point beyond the inner arch, or as far as the dotted line F shown in Figure 7. For a further consideration of instruments used for standard measurements we would refer the reader to "Standard Measurements in Machine Construction," by Mr. Fred J. Miller, "American Machinist," issues of January 7th and 21st, 1892.

CHAPTER II.

Vise Work.

As in all other branches of the machinist trade, that of the vise workman has been very much simplified by the invention and introduction of new and improved tools and appliances. Among the most important of which may be mentioned the try squares and straight edges with hardened edges, all the improved measuring instruments (to which reference has previously been made), hardened filing jigs, jigs for locating and ensuring the accurate alignment of machine parts, jigs for locating and drilling holes, and other purposes. To the above may be added the superior product of the milling and other special machines, which in many cases entirely obviate the necessity of vise work of any form whatever, and in many other cases the machines leave the surfaces of the work so nearly finished that the vise work required thereon may be said to be merely of a corrective nature, i.e., to correct any slight inaccuracies left by the machines. Notwithstanding all the above-mentioned improvements, the vocation of the vise hand has not become obsolete in any sense whatever, but has, on the contrary, assumed a still more important position in constructive mechanics, for by the intelligent application of the tools and devices at his command he is enabled not only to simplify his own methods, but to expedite and facilitate the methods, processes and

operations of the workman and work in every other branch of the profession.

TEMPLATES.

Templates are and may be used with considerable success on a large variety of work in the machine shop and also in the blacksmith and boilersmith shops, and as these useful appliances are nearly always made by the vise hand, a knowledge of their uses and application is a matter of some importance.

In making templates for the laying out and duplication of work and of parts, the template should be made to fulfill the purpose intended, that is, there should be depressions, or lugs, whenever it is possible, at intervals, which fit into or over the piece it is to be used on, at such points as will not be subsequently changed by any future process or operation to which the piece may be subjected. The template should be so arranged as to be used for laying out as many surfaces and points as can be practically covered by one template, and it should be made also with a view to using it as a test gauge after the various operations have been completed on the piece it is used upon. By this means it is possible to duplicate work within a reasonable degree of accuracy, in most cases, sufficiently close to answer all practical purposes.

Templates for locomotive-engine frames are usually connected together by means of iron or steel bars of any thickness or width desired, and templates for fire-engine and hose-carriage frames and similar purposes are cut out in one piece from sheet iron or steel. For other purposes templates may be and are made in different ways to suit the requirements of the case. In some cases they may be so arranged that they can be used for both male and female templates, thereby avoiding the necessity of making two templates.

Templates of one kind or another may be seen in nearly every establishment doing machine or iron work, and a study of their various uses and requirements will well repay any time spent thereon.

JIGS.

The use of jigs on vise work does not appear to have been so extensively cultivated as in other branches of the trade, or even so much as their utility and merits would seem to warrant.

The accurate admeasurement of distances and alignment of holes, surfaces, and parts, can readily be secured in designing and making jigs of any kind, and these features may usually be combined so as to expedite the process the jig is intended to facilitate, but there should always be an entire absence of complication ; in fact, the designer should always aim to make the jig in such a manner that it will require no effort whatever on the part of the operator to perform the work the jig has to be used upon. So successfully have these objects been accomplished in modern practice, that by the use of jigs skilled labor has been entirely dispensed with in many instances, and in other instances with skilled help the production has been increased to a surprising extent. Jigs adapted for vise work may very properly be divided into three classes, viz. jigs used for the purpose of facilitating and ensuring the accurate alignment and the locating of one or more parts of the work with some other part or parts; drilling jigs, and filing jigs.

Jigs used for the alignment and locating of parts should be made in such manner that when the part is fitted on or into the jig no subsequent fitting will be required when the part is assembled with other parts on the machine, or whatever it belongs to.

In Figures 11 and 12 is shown side and end elevation of a jig (with rod in position) for lining up connecting rods for engines.

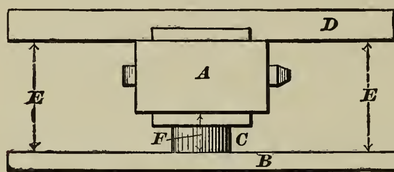


Fig. 12.

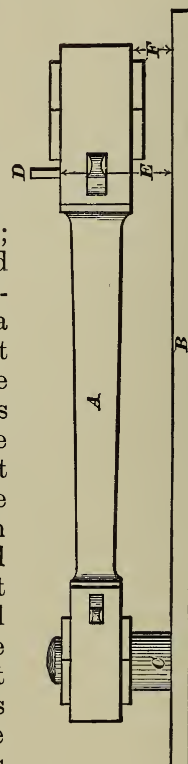


Fig. 11.

A A shows the connecting rod; B B a base plate, into which is fixed a wrist pin C C, upon which the connecting rod is suspended; D D a straight edge laid across the butt end of the connecting rod. To line up the rod laterally, the rod is placed on the wrist pin C C, the brasses are then tightened up about the same as they would be on the engine. A straight edge is then laid across the butt end of the rod at any desired point, as shown at D D. The distance is then measured from the base plate to either the upper or under side of the straight edge (as shown at E E E) by means of calipers or a surface gauge. The longitudinal alignment of the rod is secured by first measuring the distance from the base plate to either the upper or under side of the rod, as shown at F F, and then after inverting the rod upon the wrist pin C C, remeasuring the distance in the same way and at the same point. If the distances measure the same with the rod in both positions, the rod is in line, but if not, then the

brasses must be scraped or filed until it is in line. The other end of the rod is lined up in the same way, by substituting a wrist pin the right size for the brasses, or by having the plate long enough to accommodate a wrist pin for each end of the rod.

In like manner every part of any engine or machine can be fitted throughout, ready for assembling by the use of properly designed jigs, and more expeditious and accurate results obtained by their intelligent application than by any other method.

FILING JIGS.

A filing jig is an appliance used for the purpose of facilitating the process of filing the surfaces of machine parts and other articles to the shape required, thereby ensuring uniformity and accuracy of shape and size.

They are used principally on work and surfaces having an irregular shape or form; and on those surfaces of larger and heavier work to which they are adapted, or which are difficult, or inaccessible by the ordinary methods.

Among other things on which filing jigs have been successfully used are links for reversing gears, gridiron valves, cams, connecting rods and straps, gun and sewing machine parts, etc. In the author's opinion, it will usually pay to make a filing jig for almost anything upon which there is much filing or hand-work, if six or more pieces of the same have to be made.

A filing jig usually consists of two steel or iron plates with hardened edges varying from one-eighth inch to one inch in thickness, corresponding in shape to the surface or surfaces upon which they are to be used.

The plates are always connected by one or more dowel-pins, which serve to locate one plate with the

other and the work between them. The position of the dowel-pins is dependent on the nature of the work, sometimes being located on the outside of the work, but in most instances passing through the work.

Figures 13 to 17 show two forms of filing jigs and the parts upon which they were used, which, in this case, are two plates that are fitted on the side of an old-style gun and which on account of their peculiar form and other considerations will furnish good examples of these useful devices.

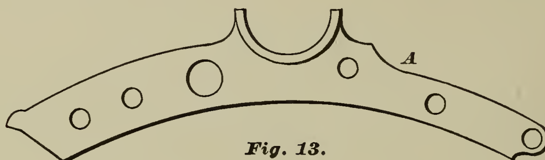


Fig. 13.

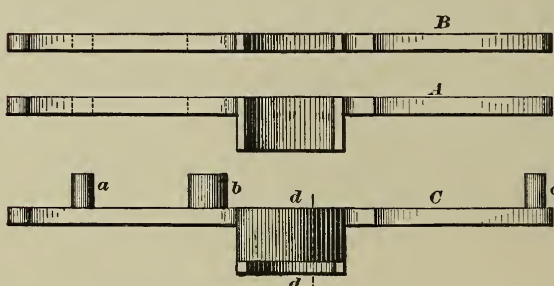


Fig. 14.

At A A (Figures 13 and 14) are shown side and plan views of the part upon which is used the first form of filing jig; B C (Figure 14) shows plan view of the filing jig, and Figure 15 section of Figure 14 at d d, showing part C.

The side view of the jig plates B and C (Figure 14) would correspond in shape to Figure 13.

In this case, three dowel-pins shown at a b c (Figure 14) and a b (Figure 15) are used, which feature is always desirable when possible, as when three or more dowel-pins can be successfully employed the opposite plate of the filing jig and also the work can be located and operated on with greater precision and accuracy.

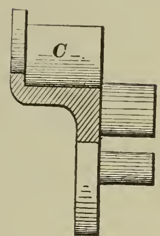


Fig. 15.

At A A (Figures 16 and 17) are shown side and plan views of the part upon which is used the second form of filing jig. B C (Figure 17) shows top (plan) view of the filing jig, the side elevation of the same corresponding to that of Figure 16.

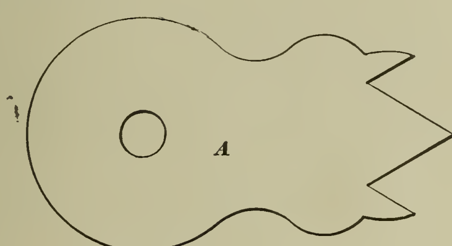


Fig. 16.

In this instance only one dowel-pin (shown at D E F [Figure 17]) can be used, as the part A A (Figures 16 and 17) has but one hole in it. In order to locate the parts B and C (Figure 17) of the filing jig correctly, the dowel-pin is turned at D to fit the hole in the work and squared at E to fit into a square hole, as shown by the dotted lines in B, thereby serving to locate the part B accurately with C. The dowel-pin is threaded at F for a nut by means of which the work

and the jig are held together. In this and similar instances two or more pieces may be filed together by extending the length of the dowel-pin or pins to suit the requirements; or when but one piece is filed at once, the jig may consist of one plate only if desired.

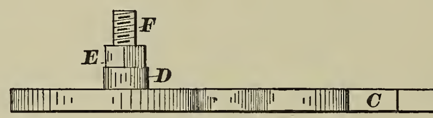


Fig. 17.

Though filing jigs rank among the very oldest appliances used for the purpose of duplicating work, they have gradually fallen into disuse in the larger establishments, except on experimental and other work where the quantity required is insufficient to warrant the cost of fitting up cutters or tools for the milling or other special machines. And in the case of the smaller concerns, the employment of filing jigs is restricted to a few isolated instances, as their use is, comparatively speaking, unknown.

CHAPTER III.

Vise Work.—*Continued.*

DRIFTS.

Drifts are used on a variety of machine-shop work in a very effective manner, and may be divided into three classes.

First. Plain drifts which enlarge the hole or slot in which they are used by expanding the same. They are used also for drawing one hole or slot into line with some other hole or slot, as on boilersmith work.

Second. Plain drifts which enlarge a hole or slot by cutting the metal away, but which have one cutting edge only upon one or more sides or surfaces of the drift.

Third. Drifts which enlarge a hole or slot by cutting the metal away, but which have one or all the surfaces of the drift serrated or notched in such a manner as to form a series of cutting edges or teeth.

For brass and composition work the first and second kinds of drifts are the best. For wrought iron and steel work either form of drift may be used, according to the requirements of the case. For cast iron work only the second and third kinds of drift can be used.

Figures 18 to 21 represent the application of the second form of drift in cutting key-ways in pulleys and fly-wheels. Figure 18 shows the drift which has only one cutting edge.

From the cutting edge A the upper surface of the drift is backed or tapered off from A to B for clearance, .002 inch to the inch in length being sufficient for this purpose. Underneath and on sides for a suitable distance of, say, from E to F the drift is made parallel. An advance guide lip or tongue C to A is intended to guide the drift when starting a cut. And for a distance of, say, from B to D, the drift is tapered off on all sides, an amount sufficient to allow for the upsetting of the end of the drift, which always occurs when the drift is driven through the work. This form of drift is far superior to the third or serrated form of

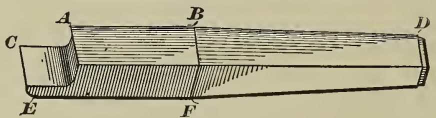


Fig. 18.

drift (which is usually employed for this purpose), as it is solid throughout its entire length, and has the additional advantage of being easy to grind (sharpen) as often as the cutting edge becomes dull.

Occasionally the sides of the drift are tapered somewhat for clearance from A to B, but if this is done at all, the amount allowed must not exceed .001 inch to the inch in length, otherwise the drift would, by successive grindings, become too narrow.

Figure 19 is a sectional view of a pulley hub A, with a guide plug B, drift C, packing shims D, plate and bolt E, all in position as the key-way F is being cut. The guide plug B is made a good sliding fit in the pulley hub. A guide groove G is then cut in the plug parallel with the axis of the plug on the sides, of the same width as the key-way to be cut, and with an amount of taper on the bottom of the groove equal to that required for the key.

The guide groove should in all cases be made deep enough to guide and steady the drift throughout the entire operation of cutting the key-way in the pulley. The thickness of the drift C is made equal to the depth of the groove on the deep end, which is equivalent to an allowance for the first cut through the work as the drift approaches the shallower end of the guide groove when the drift is driven through the work.

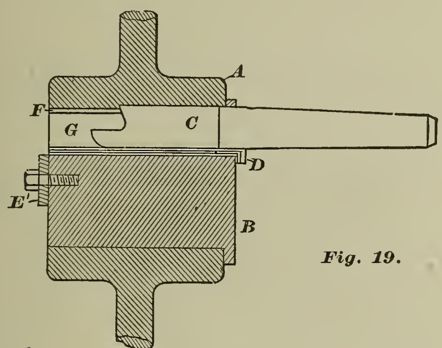


Fig. 19.

The plate and bolt E, which spans the bore of the pulley, is intended to hold the guide plug C firmly in position. A shim D, made of sheet iron or steel of the same thickness as the cut to be taken, is laid on the bottom of the guide groove after the first and each successive cut taken through the work.

DRIFT JIG.

In the design of many types of modern high-speed engines, the governing mechanism and the eccentric or eccentrics for operating the valves are located in the fly-wheel of the engine, or in an extra wheel or disc, the whole of the mechanism including the governor wheel or disc being fixed on the crank shaft of the engine in a position which bears a

definite relation to that of the crank pin or crank. In each and every form of this style of governor there is always located at some point on or within the governor wheel or disc a hub or pin from which an arm from the eccentric (where the eccentric moves across the shaft) or the principal lever or levers of the actuating mechanism (where the eccentric or eccentrics rotate on the shaft) are pivoted, and on these points more than upon anything else depends the accuracy

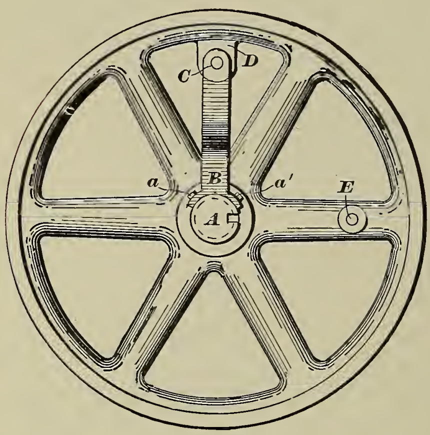


Fig. 20.

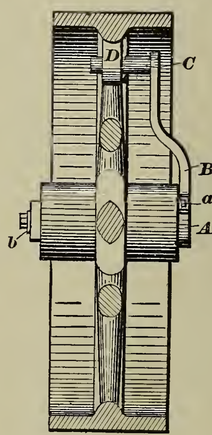


Fig. 21.

of the whole governing mechanism and valve movements. It is therefore evident that the key-seat in the crank shaft and the key-way in the governor wheel or disc may both be cut (by using suitable locating appliances) in such a position as to bear a definite relation to each other and to the crank or crank pin of the engine, and that when the governor wheel or disc is properly keyed on the crank shaft, it will be absolutely correct.

To accomplish this in the governor wheel or disc, either one of two methods may be employed.

First. After turning and boring the governor wheel or disc, to drill the pivot hole (mentioned above) and then to jig from that to the key-way, whether the key-way is cut by machine, or drifted, or cut by hand.

Second. To cut the key-way first and then to locate the holes for the pivot pins from that by jigging.

Figures 20 and 21 represent the method employed with a jigged drift plug, using the most important pivot pin-hole as the location point for the jig. Figure 20 shows a side elevation, and Figure 21 end elevation, partly in section of governor wheel and drift plug jig in position ready for cutting the key-way; similar reference letters denoting the same parts in each figure.

A A represents the drift plug, B B arm of jig, C C pin for locating the jig in pivot pin-hole, D D and E lug and hub, or boss in which the pivot pins are located, either one of which may be used as the point for locating the jig as preferred ; a a and a′ method of attaching or fixing the jig arm to the drift plug, b cross-plate and bolt.

It will readily be seen that the above principle may be extended to cover the locating of double cranks, which are usually set to a definite angle, as in locomotive practice, and may also be applied to eccentrics and cams which are keyed on the shaft, and to a variety of other purposes.

KEYS.

Fitting a key in a pulley or other work is generally regarded as a very simple matter, and so it is, when the conditions are all favorable to the operation and the underlying principles thoroughly understood.

There is, as in all such cases, some diversity of opinion on this as on other subjects, some regulating their practice to suit known conditions existing in their own particular case, and others regulating their practice to suit their own individual preferences.

A key improperly fitted may sometimes be the cause of serious accidents, or may result in fracturing or breaking the work into which it is fitted, or may otherwise impair the alignment or accuracy of the work.

In ordinary practice the journeyman machinist has nothing to do with the proportions of the key, except to determine the amount of taper the key should have (which is in general practice about $\frac{3}{16}$ inch to the foot), these and all similar questions being usually determined by the superintendent or draftsman. In fact, we question the necessity or advisability of giving the proportions of machine parts in a treatise of this kind, the proper place for such being the text books devoted to these subjects.

To fit the key properly, first see that the key-seat in the shaft and the key-way in the pulley (or whatever the work may be) have been cut straight on the sides, and if not, rectify the inaccuracy by widening both the key-seat and the key-way just enough to straighten both. The key should then be fitted, making it a good fit, bedding firmly top and bottom, and a good tight driving fit on the sides, depending almost entirely on the side fit of the key to hold the shaft and the work together, the strain on the top and bottom of the key being merely sufficient to draw the opposite side of the bore of the work firmly up to the shaft. If a key is fitted in this manner, there is no danger of throwing the work out of line, or of fracturing or breaking the hub. It is practically impossible to break a hub by making the key fit tight on the sides, or to throw the work out of line from the same cause,

if the key-seat and key-way are straight, but it is the easiest thing in the world to break the work or throw it out of line by overstraining top and bottom. Keys for connecting rods, cross-heads and similar purposes will always give better satisfaction when they are made to fit as well on the sides as on the ends or edges, for when they are so fitted there are fewer loose-fitting straps and brasses and less liability to accident.

CHAPTER IV.

Vise Work.—*Continued.*

INSERTING PIECES IN SEAMS.

When working on iron or steel surfaces that are to be nickel plated or polished there is nothing more annoying to the machinist than the appearance of an unsightly seam in some prominent part of the work where it would be impossible to file it out without reducing the work below the size required. In all cases similar to the above the seams may be very effectively closed in the following manner without in any way reducing the size of, or weakening the work.

The edges on each side of the seam are raised by means of a small, fine-pointed cold chisel throughout the entire length of the seam, inclining the chisel to the right or left, as shown in Figures 22 and 23, which are sectional end views of the work, with chisels inclined for raising the edges of the seam, A A representing the chisel, B B the work, and a a a the raised edges. When each edge of the seam has been raised as much as required, the bottom or a portion of the seam is then flattened by means of a cold set (chisel ground flat on the end), as shown in Figure 24, A representing the set, B the work, c bottom of seam, and a a raised edges. A piece of half-round iron or steel wire is then laid in the seam with the flat side of the wire on the bottom of seam. The seam is

then closed by peening the raised edges of the seam down over the wire. Unless the seam is a very wide one, the width and depth of the seam should not exceed $\frac{1}{32}$ inch after the edges are raised and the bottom flattened.

Figure 25 is a sectional end view of the work after the seam has been closed, A representing the work, B the piece inserted in the seam. If the job has been done in a workmanlike manner, it is impossible even for an expert to discover where the seam has been closed.

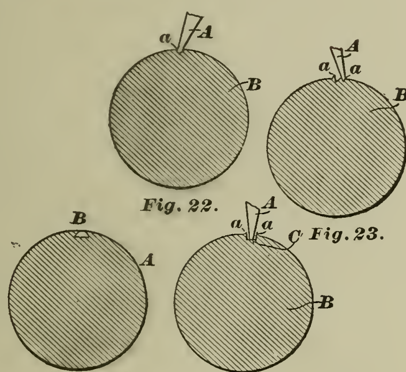


Fig. 22. *Fig. 23.* *Fig. 25.* *Fig. 24.*

Pieces of larger dimensions can be inserted in iron or steel work in much the same manner, by cutting the metal out where the imperfections exist, dovetailing the sides or the end of the work where the metal has been removed, and then beveling the ends or edges of the piece to be inserted to correspond. The piece is then bent in the center to contract the beveled edges sufficiently to admit of the piece being put into the channel or groove, after which the piece is then expanded by hammering it straight again. The edges are then closed by peening, and the piece filed down

level with the surrounding surfaces. While the insertion of large pieces may be all right in a case of emergency, if done in such place and manner as not to weaken the work to any material extent, it should only be resorted to in a case of absolute necessity, for at the best it can only be regarded as a subterfuge to cover up some imperfection that should not exist.

PEENING AND STRAIGHTENING METAL.

The peening of metal work by indenting the outer or inner surfaces of the work with the peen of a hammer in such manner as to cause the hammered surface to stretch or elongate, in order to straighten, change the shape of, open or close the work, is a method which has been practised by the machinist from time immemorial; and though it may be advisable in some cases to straighten or otherwise change the shape of the work by this method, still it can scarcely be said to be good practice where and when other and better methods are available, and it certainly is not what may be termed the approved practice of the day, nor does it improve the appearance of finished or other work to batter it out of all semblance of recognition. In the case of a connecting-rod strap that has to be opened or closed, the opening or closing may be effected in a better if not in a more expeditious manner by heating the strap slightly, and making the necessary adjustment by means of a bolt and nut, or in the vise, or by other means, without in any way marring the appearance of the work. For all wrought-iron work the above or some similar method is preferable to peening in nearly every instance. But for cast-iron work, which is warped or bent, the attempt to straighten or otherwise change the shape of the work by other means than peening is very seldom made; in fact, outside of our own individual

experience, we don't remember having seen it done more than once or twice. It is nevertheless a fact that cast iron may be heated and straightened or changed in shape by pressure, within a reasonable

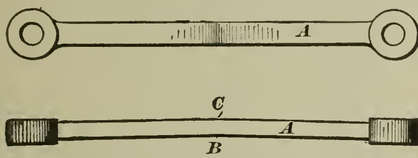


Fig. 26.

degree, by means of a press, or with a wrench holding the work in the vise after it has been heated, or with bolts and straps on the planer or other platen, or by applying the pressure by other suitable means.

Suppose the rod A to be bent as shown at B C (Figure 26).

It may be straightened by heating the rod at B C and then applying the pressure at C, in any of the above-mentioned ways. Just as soon as the rod has been straightened the pressure may be relieved and the rod laid aside to cool.

Figures 27 and 28 represent the casting for a machine frame, the standard and hubs A A′ A″ forming the bearings for one spindle or shaft, and B B′ B″ the bearings for the other shaft.

To straighten the standard A″ (Figure 28) (which has been warped in casting), to bring the hub in line before boring, the standard is heated to a red heat at a, if possible making it hottest on the side b, and only a dull red heat on the side c, as in order to straighten the standard the surface b will have to be stretched to the length of c, as it is impossible to upset or compress the surface c enough to conform to that of b. It will therefore be seen that it is easier to stretch the surface b if it is made hotter than that of

c. As soon as the standard is heated enough the hub A″ is held in the vise and pressure carefully applied until the standard is straightened. The pressure is then relieved and the frame laid aside to cool.

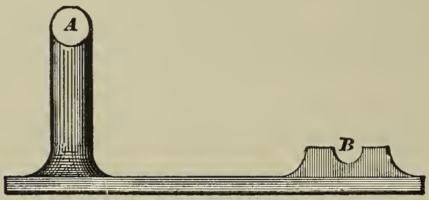


Fig. 27.

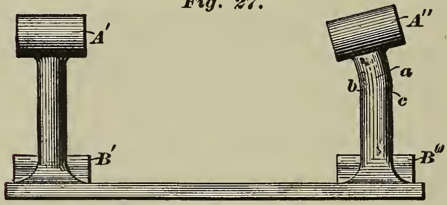


Fig. 28.

When a piece of work has been treated as above, it may, as soon as it has been bent to the shape required, be laid aside to cool, and it will not spring back again even though a cut be taken over the surface which has been bent. This one feature, if there were no other advantage in this method, should of itself recommend it to the intelligent mechanic. Many castings which are now discarded because they have been warped in casting could be restored in this manner at a trifling cost, all that is necessary being ordinary care and judgment.

CHAPTER V.

Chasing.

Chasing is the art of finishing bronze, composition, and other soft metal art and ornamental work, by

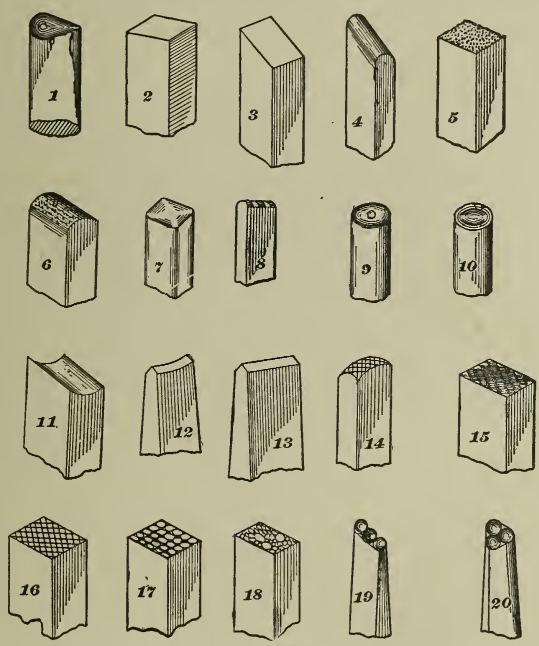


Fig. 29.

means of scrapers, burnishers, and a variety of other instruments in the form of punches of different shapes

and sizes, the metal being cut away from or driven into the body of the work, and the design, if any, on the face of the punch is conferred to or upon the work by the action of the punch and hammers.

Though this art forms no part of the machinist's branch of mechanics, yet a knowledge of the chaser's tools and their application can be used to good advantage by the machinist in finishing ornate pattern and other work, almost to the entire exclusion of any other method, and also in finishing other work difficult of access by the ordinary methods.

Figure 29 represents a number of different forms of the chaser's punch tools, the size of the faces of the

Fig. 30.

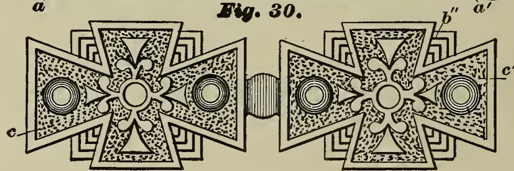


Fig. 31.

punches varying from $\frac{1}{16}$ inch by $\frac{1}{64}$ inch to $\frac{1}{4}$ inch by $\frac{3}{8}$ inch, and the length from 4 to 5 inches, according to the requirements and nature of the work.

No. 1 represents a loup tool, the face of which is egg-shaped, used for finishing the fillets in corners and along the abutting surfaces of the work.

No. 2. Planisher. For producing a smooth surface, generally used for finishing the recessed surfaces of work, such as shown on the under side of the pattern at a a′ (Figure 30).

No. 3. Side planisher. For finishing the flanged or other edges of recessed or relief work, such as shown at b b′ b″ (Figures 30 and 31).

No. 4. Half-round planisher. For finishing the inside of grooves, along fillets, etc., such as a a′ (Figures 32 and 33).

No. 5. Flat planisher. For producing a slightly matted surface on work, such as shown at c c′ (Figure 31).

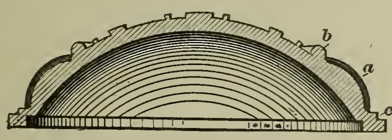


Fig. 32.

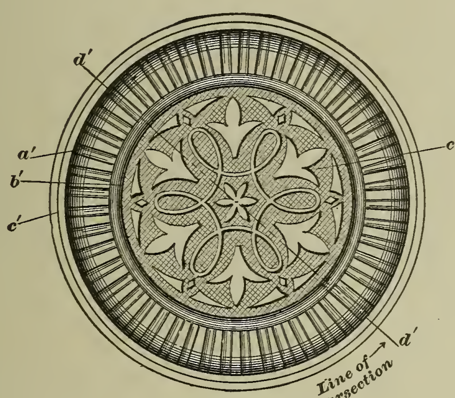


Fig. 33.

No. 6. Half-round (convex or male) planisher. For producing a slightly matted surface on grooved and other work.

No. 7. Plain planisher with edges slightly rounded off.

No. 8. Half-round cross-grooved tracer. For making and finishing borders on ornate work.

Nos. 9 and 10. Male and female beading tools. For finishing the beads and cuplike depressions on ornate work.

No. 11. Half-round (concave) tracer. For finishing half-round or round borders and similar work, such as b b′ (Figures 32 and 33).

No. 12. Plain semicircular tracer. For finishing along the flanges or corners of round and other curved work, such as c c′ (Figures 32 and 33).

No. 13. Plain tracer. For finishing along the corners and elsewhere of plain work.

Nos. 14 to 18. Matting tools. For producing heavier or deeper matted surfaces, one form of which is shown at c (Figure 33).

Nos. 19 and 20. Other forms of beading tools. Any and all of the above chasing tools are made male or female as required to produce an embossed or indented matted or other appearance.

When the work to be chased is flat and has no recesses on the under or opposite side of it, and the form is such that it cannot be held in the vise while being chased, the work is held on a plate of cast or wrought iron with common solder. The plate may be from ½ inch to 1 inch in thickness, and of such size otherwise as to admit of one or more pieces of the work to be chased being soldered on the top of it. On the under side of the plate are lugs or projections, by which it is held in the vise. The top of the plate should first receive a coating of common solder, and while the plate is still hot enough for the solder to flow, the work is (after being straightened on the opposite or under side by means of a wooden or raw-hide mallet) laid on the plate to which it will adhere, and then cooled off. After the work has been operated on, the plate is again heated and the work taken off.

In other cases where the inner or under side of the work is of such shape that it cannot be soldered onto

the above-mentioned plate or held in the vise, it is sometimes held by means of a leather strap on a block of wood cut out to fit the work or on a sand-bag; the work being placed on the block or bag, and held by the strap, applying the pressure (to hold it down) with the foot.

When the form or shape of the work is such that it cannot be held while being chased or operated on by any of the above methods, as in the case of the pattern (Figures 30, 31, 32 and 33), where the inner or under side of the patterns are recessed, the work, with the exception of the surface to be operated on, is imbedded in a block of composition made of resin of ordinary grade and plaster of paris, equal parts, to which is added (about one ounce to the pound of composition) tallow (candles), the whole being mixed together by heating in an iron pan or kettle, the resin being melted first, then the plaster of paris being gradually stirred in with the melted resin, after which the tallow is added, and the mass poured out to form a block of suitable size, and allowed to cool. To imbed the work, the top surface of the block is again softened by heating it with a bunsen burner or blow-pipe; the heated surface is then pressed or kneaded to such shape as will approximately conform to the recesses and shape of the work. The work is then pressed down as far as required into the composition, which is then squeezed well up to the work all round and allowed to cool.

The work is finished by hammering the surfaces down with the punches and hammer in such a manner as to leave them perfectly smooth, or to confer the design (if any) on the punch to the surface of the work. Of course, it will be understood that the action of the hammer and punches on such work as Figures 30 and 31 will be analogous to that of peening, and therefore has a tendency to warp or change the

shape of the work; but as the work is always made of bronze, composition, or other soft or malleable metal, it can be readily straightened and restored to shape with a wooden or raw-hide mallet.

$d'd''$ (Figure 33) shows line of intersection for Figure 32.

CHAPTER VI.

ERECTING.

General erecting or that branch of the machinist's trade which consists in the assembling together, mounting, or erecting of engines, machinery, or other work (either during or after the parts which constitute the whole have been fitted together), should be carefully and closely studied by every apprentice or machinist that desires to attain any prominence as a mechanic.

A knowledge and familiarity of and with the principles involved; and the methods adapted to and employed in the general erection of machinery and other work is an absolute necessity, and should be very thoroughly acquired.

The erector should furnish for his own use such tools as are adapted to the work he has to do, and the tools should be as few in number as possible, and should be used with such care as only a good mechanic can bestow.

It may be frequently observed that a certain mechanic is credited with being a better workman than his associates, not because he is a better mechanic than they are, but simply because he has intelligence and enterprise enough to procure for his own use tools of a superior grade, which are adapted to the work he has to do, and by the use of which he is enabled to do his work more accurately and expeditiously than his associates, thereby and justly earning for himself the reputation of being a better mechanic than they are,

SETTING OR LINING SHAFTING.

When the machinist is called upon to set up a line of shafting, it is very seldom that he finds anything in the way of suitable appliances with which to do or facilitate the operation of setting or lining the shafting. The most practical and successful way to set a line of shafting is to use a transit level, but there is not over one establishment in a hundred where such an instrument is available, or where the ordinary machinist is acquainted with its use, and consequently the machinist must use such appliances as are available, or make some that are adapted to this purpose.

Many machinists simply use an ordinary spirit level laid on the top of the line shaft at suitable intervals to secure the horizontal alignment of the shafting, and a stretched cord for obtaining the lateral or longitudinal alignment.

When no other appliance is used for securing the horizontal alignment of the line shaft than an ordinary spirit level, it will be found practically impossible to make the shaft accurate, for the simple reason that an ordinary spirit level is not a very reliable instrument. If a spirit level is used at all, it should be of the very best make that can be procured, and should then be used only in connection with some other appliance, such as will secure an absolutely correct alignment of the line shaft. And therefore if the establishment where the machinist is employed does not possess a good reliable spirit level, the machinist should provide one for his own use, whatever the cost may be. A good spirit level is practically indispensable to the erector, for it can be applied to ensure the horizontal and vertical alignment of work in a thousand places, and will often give more accurate results than either squares or straight edges.

In the following examples are shown some excel-

lent devices for setting or lining line shafting. They are such as can be made by any good mechanic, and such as will give very accurate results.

To set up a line of shafting, the first thing to be done is to stretch a chalked line close to the ceiling of the shop or building in a line parallel to the axis the line shaft is intended to occupy; then by snapping the line in the usual way, the result is a chalk line the whole length the line shaft is to be. This chalk line is to serve as a temporary line from which, by means of a plumb-line, or by measuring otherwise, each hanger or bracket may be approximately located and fixed in a position corresponding to the longitudinal alignment for the shafting, the horizontal alignment of the boxes or bearings being approximately determined by placing a parallel rod or straight edge in the first two, and then in each bearing in succession, leveling them with a spirit level. The shafting can now be placed in position in the bearings and the permanent alignment of the same proceeded with. For the permanent longitudinal alignment of the shafting a strong, fine line of cord or string is to be tightly stretched in a line parallel to the longitudinal axis of the line shaft, fixing it either directly below and in a vertical plane with the axis of the line shaft, or, if for other considerations, to one side of the same as much as deemed necessary; then by suspending a plumb-line from the shafting, and measuring from that to the stretched cord, the longitudinal alignment of the line shaft can be accurately obtained.

Simultaneously with the above operation, the permanent horizontal alignment of the line shaft may be proceeded with by means of the mounted straight edge and spirit level shown in Figure 34, where A A represents the line shaft, B B V blocks, C straight edge, D spirit level, E E E hanger brackets, F stretched cord or line, G G plumb-line.

In many cases where a line shaft has to be reset or relined, or where it is necessary to put all or part of the pulleys on the line shaft prior to placing it in the bearings, the mounted straight edge shown in Figure 34 may be inept for the purpose, in which case the

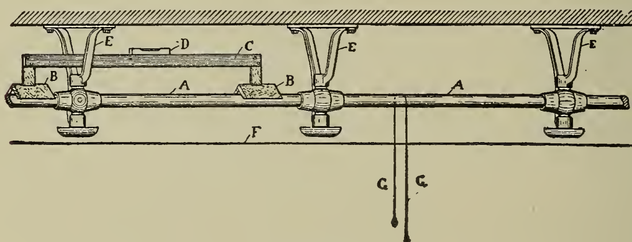


Fig. 34.

straight edge may be suspended below the line shaft and pulleys, as shown in Figure 35, in which the same reference letters denote the same relative parts as in Figure 34, the method of alignment being also practically the same.

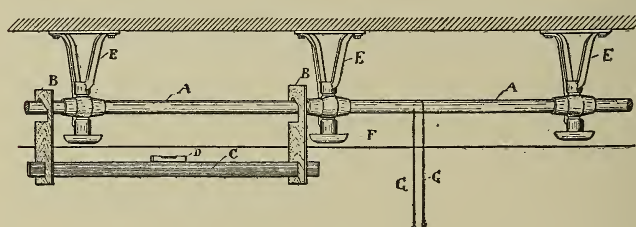


Fig. 35.

In Figure 36 is shown a method of leveling a line shaft from points located at suitable distances along the floor of the shop or building which will give very accurate and satisfactory results if done in a workmanlike manner; in fact, it is doubtful if anything more

accurate can be devised for the purpose. In the figure referred to A represents a water level, which is merely a trough about 4 inches wide 3 inches deep, and 12 feet or more in length, according to the requirements of the case, but not to be less than the distance from one hanger bearing to the other. The depth of the level must be exactly the same at each end; that is, from the underside of the level to the top of the end piece of the same; otherwise the level will not be accurate. The sides of the level should be slightly higher in the center than on the ends, to prevent the water from flowing over the sides of the level before it flows over the ends, when the level is filled with water; B B′ B″ wooden blocks nailed to the floor, C a pole about 1 or $1\frac{1}{2}$ inches diameter and of such length as will reach from the top of the blocks on the floor to the underside of the line shaft, an ordinary wood screw with the heads filed off being screwed into each end of the pole to form the measuring terminals, D D line shaft, E E E hangers.

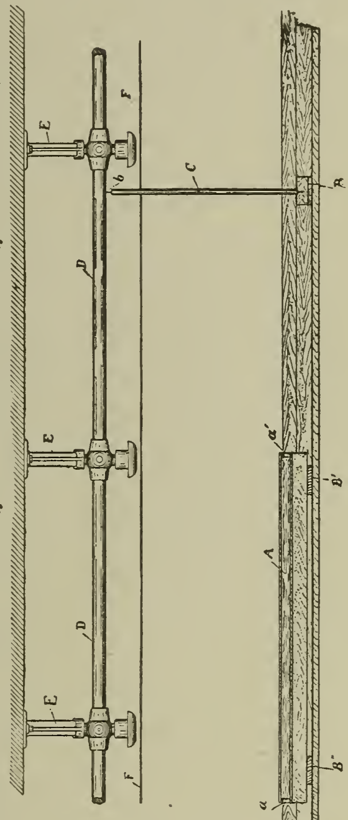


Fig. 36.

To set a line shaft by this method the plan of

proceeding is as follows: If preferred, the line shaft may be first approximately aligned as outlined in the preceding examples. A chalked line should then be stretched along the floor in a line parallel with the axis of the line shaft. The line is then snapped in the usual way to make a chalk line along the floor. Then on the floor directly underneath the line shaft and at a point about 4 or 6 inches past the end of the hanger bearing a block of wood of any thickness desired is nailed to the floor as shown at B; similar blocks are then nailed to the floor in the same relative position just past the end of each of the other hanger bearings in succession, as shown at B′ B″. The tops of the blocks B B′ are then planed off until they are perfectly level as determined by the water level A (which will be shown on gradually filling the level with water until the water flows over each end simultaneously). When these two blocks are perfectly level, the level is then transferred to the blocks B′ B″, and the block B″ is planed off until it is level with the block B′, and so on, until all the blocks are perfectly level. The tram rod C is then adjusted to measure the distance exactly from the top of the block B to the underside of the line shaft, as shown at B b. The line shaft is then adjusted until it measures the same from the top of each block to the underside of the line shaft at each hanger in succession.

The longitudinal alignment of the line shaft is obtained in the same manner as in the preceding examples, with a stretched line or cord and a plumb-line.

A straight edge and spirit level may be used for leveling the blocks on the floor, if preferred, instead of the water level. But unless both are of extra fine make, they will not give the same accurate results as the water level.

The wooden blocks on the floor should not be dis-

turbed until all the machinery is in position and the pulleys and belts put on, as it is a good plan to give the line shaft a final testing after everything is set up and belted up, thereby correcting any possible deflection occasioned by the strain from the belting.

It not infrequently happens that a line shaft extends or has to be extended through the wall from one room or building to some other room or building, and that it is a difficult matter to secure a correct longitudinal alignment of the extension of the line shaft, owing to the limited space in the wall boxes, which in some cases is barely sufficient to admit the bearing for the line shaft therein. In such cases the stretched line or cord referred to in the preceding examples should be stretched as far to one side of the line shaft as will allow it to clear the bearing. When this is possible the stretched cord can usually be aligned by means of plumb-lines suspended on that portion of the line shaft already set up, as the stretched cord can then be suspended below the axis of the line shaft; but when the space occupied by the bearing precludes the possibility of suspending the stretched cord below the axis of the line shaft, then the cord should be suspended on a line level with the horizontal axis of the line shaft, or if necessary, even a little above the axial line of the shaft, the longitudinal alignment of the cord being obtained, as shown in Figure 37, by means of two or more wooden tram-pieces, one end of which is made V shape, and the other end square with the edges.

Figure 37 represents plan (top) view of line shaft and extension of the same; A A′ line shaft, B B′ hangers, C shaft bearing in wall box, D wall box, E E′ wooden tram-pieces, F F stretched cord, G G section of wall, A″ sectional end view of shaft, E″″ side view of wooden tram-pieces, E″ E‴ dotted lines showing manner of lining up extension of

line shaft by means of the wooden tram-pieces. The end of the stretched cord is tied to the shaft or elsewhere, as shown at a, the cord is then stretched and the tram-piece E is inserted between the cord and the line shaft, by which means it is held in contact with the line shaft, acting as a fixed distance piece between the line shaft and the cord. The cord is then aligned longitudinally by holding the second tram-piece E′ in contact with the line shaft, and adjusting the cord until it just touches the end of the tram-piece. When the cord has been fastened in that position, the alignment of the extension of the line shaft may be proceeded with by the same means employed for the rest of the line shaft. If the stretched cord is a very long one, the longitudinal alignment of the cord may be somewhat effected by currents of air, in which case the cord may be prevented from swaying by means of weights suspended on strings from nails driven into the ceiling in a perpendicular line with the cord.

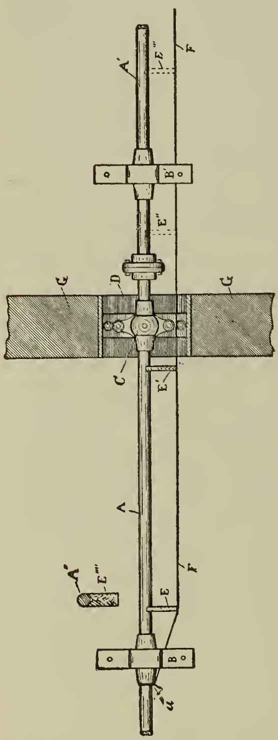


Fig. 37.

MOVING AND SETTING MACHINERY.

In setting up machinery, due regard should be paid to the disposition and position of each and every machine that has to be set up.

For instance, in determining the position of the various machine tools in a shop building steam engines, each machine should be located in a position the most favorable to the work to be done on it, as in the case of the machines for performing the various operations on the bed-plates and cylinders of the engines. The first operation on the bed-plate is the planing; the second, the boring and turning; the third, the drilling. And on the cylinders, the first operation is the boring; the second, the planing; the third, drilling. It is therefore evident that the position of the machines mentioned should be such that the work can be readily transferred from one machine to the other as the various operations are to be performed thereon. And in like manner, the position of every machine should be carefully considered.

There are many other important factors which are likely to enter into the consideration of the question as to where and how the machines should be located, such as the position the countershafts for the various machines must occupy without conflicting with the working of each other. Then again, the space occupied by the traveling or jib cranes, or the trolley ways for conveying and transferring the work to and from the machines and elsewhere, will assuredly have something to do with the locating of the various machines.

Therefore, from these and other considerations, the importance of having all the conditions thoroughly understood and of making a detail plan drawing of everything to be set up will be readily seen.

The transportation or moving of heavy machines to their places on the foundations is often a matter of some difficulty. Skids and rollers are always utilized when they are available, but as a general thing they can only be used for moving the machinery in one direction, and resort must be had to blocking and

levers for moving the machinery in a lateral or transverse direction onto the foundation, which is not only a slow and tedious process, but also expensive.

The method of moving heavy machinery, shown in Figure 38, has proved very successful in our own practice, and we can recommend it for moving heavy machinery very quickly in any direction. The plan consists in placing a plank or beam of wood under the feet or frame of the machine facing the direction the machine has to be moved, and then attaching a sling around the machine and another sling over

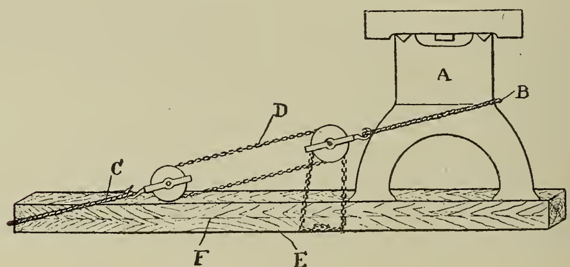


Fig. 38.

the extreme end of the plank or beam and connecting the two slings by means of a tackle block, as shown at B C D, where A represents the extreme end of a planer bed and platen, B sling around the standard of the same, C sling across the end of the plank E upon which the planer rests, D tackle block which connects the slings B and C. When moving a machine in a transverse direction, a tackle block may be used on each end of the machine, so that each end may be moved in unison, and when moving the machine in the direction of its length, either one or two tackles may be used; if one is used a bar should be placed

across the extreme ends of the planks, and the tackle block hooked onto that. The only thing necessary to be observed in using this appliance is to get the sling on the machine as low as compatible with safety to the machine legs, and to get the sling C (on the end of the plank) below the median line F of the plank, to prevent the latter from raising.

When a machine has been placed in position on its foundations it should be very carefully aligned horizontally and transversely by means of a straight edge and level, raising any particular part of the machine that happens to be lower than the surrounding surfaces of the same by inserting iron or wooden wedges under the frame or feet, directly under that part of the machine which is lowest.

Narrow iron or wooden wedges may be inserted under all the feet or all around the frame of the machine at suitable intervals and the machine raised about $\frac{1}{4}$ inch above the foundation. The machine may then be leveled by driving the wedges in, or drawing them out, as required. A bank of clay or putty may then be put all around the feet or frame of the machine in the usual way, and the space between the bottom of the feet or frame of the machine and its foundation filled up by pouring either mixed portland cement or melted sulphur (brimstone) therein. When this is thoroughly set or hardened it forms a good solid foundation, which will seldom give any further trouble.

In setting small lathes or other machines, melted spelter is often used to pour under the feet of the machines instead of the portland cement or sulphur, or hardwood blocks may be used for the same purpose if preferred.

CHAPTER VII.

ERECTING.—*Continued.*

ERECTING A TRACTION ENGINE.

The erection of a traction engine furnishes an excellent example of the practical application of many of the principles involved and the methods which are employed in general erecting, for there is such a variety of parts to be located and aligned that a knowledge of the methods employed in locating and aligning many of these parts cannot fail to be instructive in the highest degree.

A traction engine with locomotive type of boiler has been selected for the purpose of illustrating the methods employed, as many of these methods are identical with those employed in locomotive construction in erecting similar parts, the principles being the same throughout in both cases. All the parts and attachments located on the under side of the boiler are always fitted to place before any of the upper parts and attachments are fitted. These parts can be fitted much easier and better if the boiler is inverted (turned upside down).

The parts which are fitted on the under side of a traction engine boiler are generally such as can be fitted without any special appliances or fixtures, using a spirit level for any necessary alignment of the parts. But when, as in locomotive practice, all or many of the parts on the under side of the boiler are fitted and

aligned with due reference to a center line, as in the case of the cylinders, frames, etc., the center line is obtained in the same manner as explained in Figure 41. Before proceeding with the fitting of any of the parts, the boiler must be aligned in two and sometimes in three directions, viz., vertically, horizontally and longitudinally.

When the boiler has been inverted, a center line A A (Figure 39) should be made on the back end of the boiler, first describing the arcs a a a a with the trams (abbreviation for trammels) from the points b b b b and then continuing the center line from A to A with a straight edge and scriber (scratch awl). The boiler is then aligned vertically from this center line

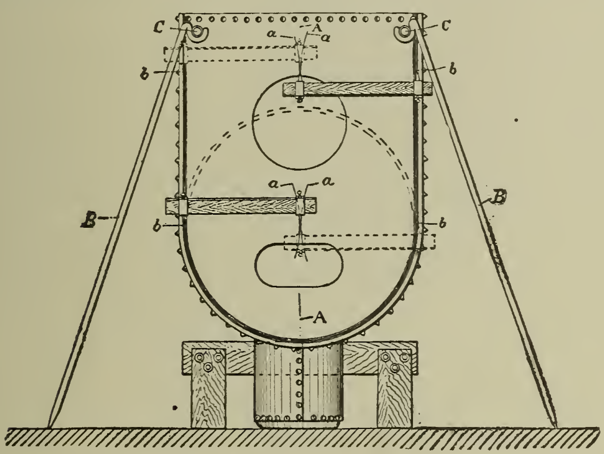


Fig. 39.

by means of a plumb-line, and is supported in the vertical position by means of the rods B B, one end of which is spiked into the floor and the other end hooked to fit the nipples C C which are screwed into the plug holes of the boiler.

The horizontal alignment of the boiler is obtained by means of a straight edge and level placed on small parallels on top of the cylindrical part of the boiler in front of the fire box.

When all the parts have been fitted on the under side of the boiler, the boiler may be turned over and re-aligned for the permanent erection and fitting of all the parts. In some cases it may be necessary to remove some of the parts on the under side of boiler to avoid breaking the same when turning the boiler over.

When the boiler has been turned over it should be mounted in a suitable way on blocking, as shown in Figure 40, with one or more blocks under the fire

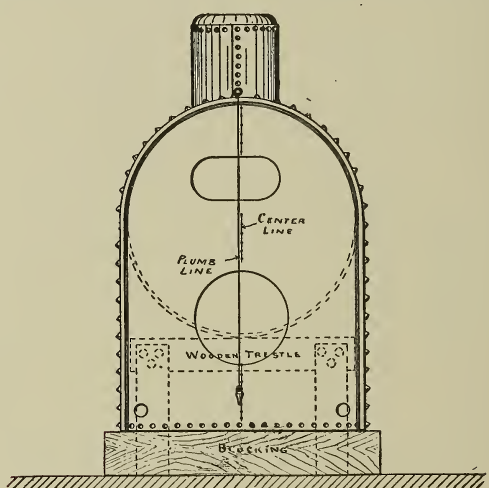


Fig. 40.

box and a wooden trestle (or horse) under the fore end (cylindrical part) of the boiler. The boiler is then permanently aligned in the same manner as employed in aligning the under side of the boiler,

the vertical alignment by means of a plumb-line (as shown in an obvious manner in the Figure), and the horizontal alignment by placing a straight edge and spirit level on small parallels on the top of the cylindrical parts of the boiler.

A center line is then made on the top of the boiler parallel to the longitudinal axis of the same by means of a square and level, as shown in Figure 41, where a a represents the center line on top of boiler,

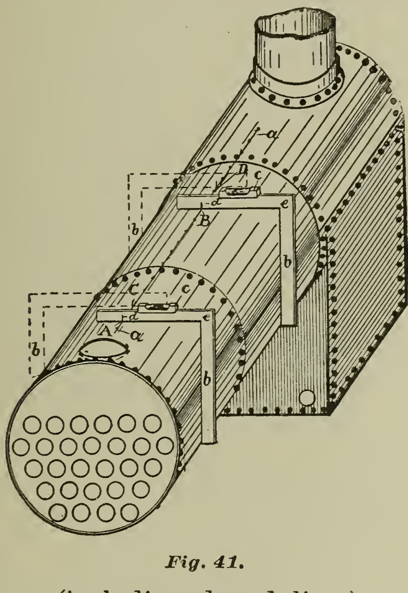


Fig. 41.

b b b b square (including dotted lines), c c level, and d d line on square from which the center line on boiler is obtained.

To obtain the center line, a square (which may be either wood or steel) is placed with one blade resting on top of boiler at A and the other blade touching the side of the same. The upper blade of the square

is then leveled by means of a spirit level, and the line d (the distance of which from e to d should be equal to the radius of the outer diameter of the boiler) is transferred to the boiler. The square is then transferred to B C D in succession and the operation repeated. When these four points have been made the center line is made by making and continuing (with a straight edge) a line directly through or between these four points along the top of the boiler from the fore end of the smoke box to or beyond the dome.

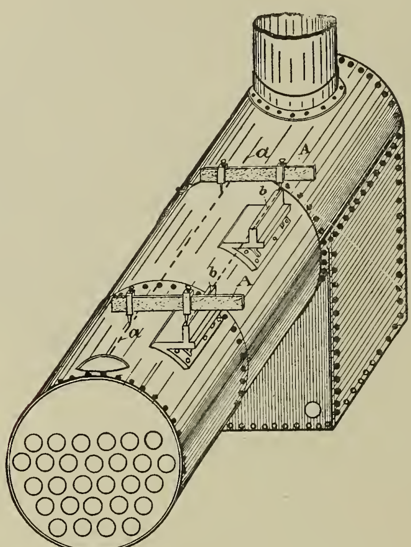


Fig. 42.

When the above operation has been completed and the center line obtained, the cylinder brackets may then be aligned and located in the following manner: (The brackets are placed in position on the boiler and supported by wooden props while being fitted.)

The brackets are aligned in four directions, viz., longitudinally, transversely, horizontally and vertically. The operation of aligning the brackets longitudinally and transversely are conducted simultaneously, the longitudinal alignment by means of the trams A A, shown in Figure 42, which determines the distance of the brackets from the center line a a, as indicated by the line b b.

The transverse alignment and height of the brackets are obtained and determined by means of the tram-board A (Figure 43), which is placed on the top

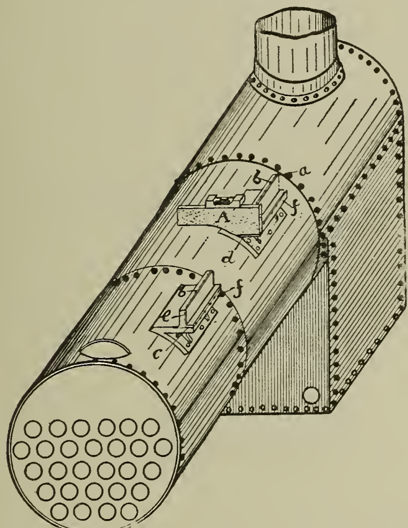


Fig. 43.

of the boiler and leveled as therein shown. The line c (shown on the forward bracket) is drawn transversely across the bracket from the under side of the tram-board, as shown at d.

The vertical line (shown also on the forward bracket) is obtained by placing a square on the end

of the brackets with the blade pointing downwards; then if the stock of the square is leveled with a spirit level, the blade will be in a perpendicular position and the vertical line e may be drawn from b to intersect the line c.

The horizontal line f f is obtained by continuing the line c along the outer surface of the brackets by means of a straight edge and level.

Cylinder brackets and other parts and fittings which have to be fitted and bolted to the boiler always have chipping pieces, flanges, or ribs, which are to be chipped and filed away until the part is closely fitted to the boiler, the chipping and filing of which must be done in such manner as to facilitate the locating and ensure the correct alignment of the part in all directions.

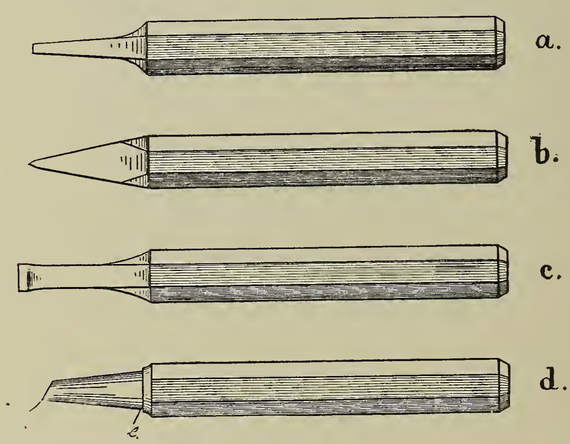


Fig. 44.

When the cylinder brackets have been fitted and correctly aligned in all directions the position of the bolt holes (which have been previously drilled or cast in the brackets) is marked out on the boiler, usually

by means of a piece of piping (which has been turned to fit the holes) the end of which has been slightly smeared with red lead, or by means of a scriber (scratch awl). The brackets are then removed and the outlines of the holes marked with a center punch, after which the holes in the boiler are cut and drifted to tapping size, using for this purpose what is termed a "cape" chisel (which differs from a "cross-cut" chisel by being tapered off to a point on all sides) and drift, as shown in Figure 44, in which a and b represent an edge and side view of cape chisel, c cross-cut chisel, d drift, which is turned taper and of the same size on the large end at e as a tapping drill would be for the size of tap required. The drift is ground away on the small end at f to form a cutting edge to cut away any burrs which may be left in "capeing." The holes are then drifted to size and tapped out, care being taken to tap the holes to the angle at which the bolts should enter the boiler. The brackets are then replaced and temporarily bolted to the boiler, after which they are re-aligned and the lines center punched in the usual way; they are then taken off the boiler again and planed to the lines marked out on the brackets, using the lines first to set the brackets by on the planer or shaper, and then planing the surfaces to these marks or lines.

After the brackets are planed they are again bolted temporarily to the boiler and tested for parallelism with a straight edge. The cylinder (which has been previously planed and drilled) is then placed in position on the brackets and held by clamps while the bolt holes are marked out on the brackets. (Preference is given this method of marking the holes for the bolts which hold the cylinder to the brackets, as more accurate results can be obtained and less trouble is experienced than when the holes are jigged.)

The brackets are again taken off the boiler and the

holes for the cylinder bolts drilled therein, but in this instance, instead of drilling the holes concentric with the lines marked out on the brackets, the holes are drilled slightly out of center (possibly 2-1000 inch) in the direction of the lines f f on the brackets (Figure 43), the result of which is that when the bolts (which are turned to fit the holes) are driven into the holes the cylinder and the brackets are drawn closer together, thereby avoiding any possibility of the cylinder ever becoming loose on the brackets through the jarring and vibrations to which it is constantly subjected.

The brackets may now be permanently bolted to the boiler, this time using new bolts smeared with red lead, screwing them up just sufficient to hold them in place. They are again tested with straight edge and level for the final alignment, after which the cylinder is placed and clamped in position on the brackets, the holes for the cylinder bolts reamed out, and the bolts inserted and tightened up.

The cylinder is then tested on the planed surfaces of the steam chest or valve seats for the vertical alignment, tipping the upper or lower parts of the brackets by inserting thin wedges or strips under the corners of the same to throw the cylinder in the direction required if any change is necessary.

The space between the boiler and the outer edges on the sides and bottom of the brackets is then closed either with putty or with clay that has been carefully prepared for the purpose, leaving the space open between the boiler and the upper edge of the brackets. The internal space between the boiler and the brackets is then filled up with molten spelter (zinc), pouring it in through the opening left on top of the brackets. Great care must be exercised in filling up this space with the molten metal, for if any moisture exists or is generated (by sweating) on

either the boiler or bracket the metal is liable to explode and fly out to the injury of the operator.

When the metal has cooled off, the bolts which hold the brackets to the boiler may be tightened up as much as necessary to hold the brackets and cylinder permanently in position. Any surplus spelter is then trimmed off even with the edge of the brackets.

The toe bracket a (Figure 45) is then fitted and bolted to place under the planed surface of the tail-piece b, and the space between the boiler and the

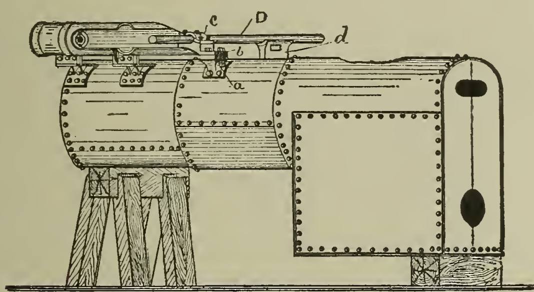


Fig. 45.

bracket filled in with molten spelter in the same manner as the cylinder bracket.

The crank-shaft bearing c should now be fitted and babbitted (in traction engine work the crank-shaft bearings are usually babbitted, the ends of the bearings being planed off at the same time as the guide-ways, steam chests, and valve seats). Sometimes the number of engines to be made would scarcely warrant the cost of making any expensive appliance for aligning and babbitting the crank-shaft bearings, in which case the babbitting plug shown in Figure 46 may be used, A representing the babbitting plug, which is a solid plug turned to the same size as the crank-shaft journal with a flange B on one end, C

loose washer which fits the body of plug, D and E washer and bolt for holding the plug in position. When the bearing has been prepared for babbitting one or more thin pasteboard or sheet-iron liners are placed between the two halves of the bearing with the edge A (Figure 47) (which should when pouring both halves of the bearing together have V-shaped notches [shown at B] cut at intervals throughout the length of the same to permit of the babbitt-metal

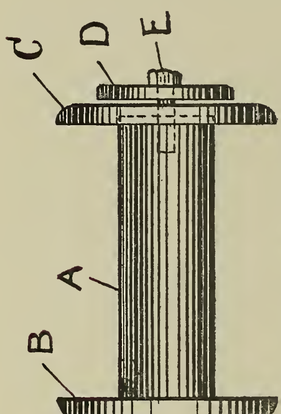


Fig. 46.

Fig. 47.

flowing from one part of the box to the other) in close contact with the side of the babbitting plug. When these liners have been adjusted the cap (of the bearing) may be screwed down tight. The babbitting plug is aligned transversely and horizontally by bolting it in position, so that the turned face of the flange B (Figure 46) comes in direct contact with the planed or faced surface on the end of the bearing. The height of the axis of the plug (and of the axis of the crank shaft) is determined by squaring from a marked center on the outer surface of the flange B of the babbitting

plug to a stretched center line drawn through the center of the cylinder bore and guides.

The bearing may then be babbitted, after which the cap can be taken off and the plug removed. A hollow mandrel (made of turned piping or tubing) of the same diameter as the crank-shaft journals (less the amount allowed for scraping or reaming the bearings to size) and long enough to reach across the boiler is then placed and bolted in the bearing. The pillow block or off-side bearing d (Figure 45) of the crank

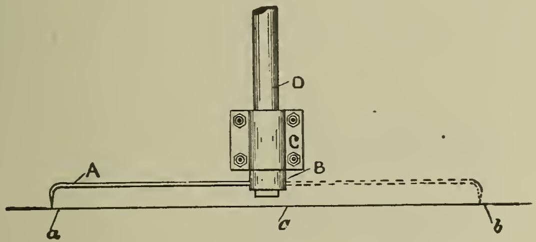


Fig. 48.

shaft is then fitted and aligned to this mandrel and fitted and bolted to the boiler, and the space between the boiler and the saddles of the pillow-block bracket is filled with spelter (as with the other brackets). When the pillow-block bracket has been fitted and bolted to the boiler, the box or bearing is prepared for babbitting, placing one or more liners between the two halves of the same (as in the other bearing). A solid babbitting mandrel can now (if preferred) be substituted for the hollow one; this mandrel must be tested to see that the alignment is correct, being tested for the horizontal alignment by means of a spirit level, and for the transverse alignment by squaring from the mandrel to a stretched line or cord drawn through the center of the cylinder and guides, or to the planed surfaces on

the end of the near-side bearing of the crank shaft, or by using the collar tram, shown in Figure 48, which represents a plan view of the bearing c, the mandrel D, the collar tram A B, and the stretched line or cord C (which is drawn through the center of the cylinder and guides) in position. To test the mandrel D with this device for the transverse alignment, the collar B (which should be a good fit on the end of the mandrel) is placed on the end of the mandrel D and pressed close up to the bearing c; the tram point A is then adjusted to just touch the line C at a, the tram point is then transferred to b (always keeping the collar B pressed close up to the bearing c), and if the

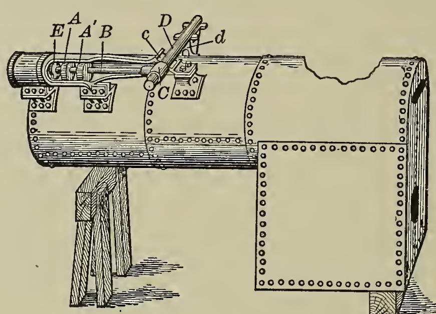


Fig. 49.

tram point touches the line C, the same at b as at a, the alignment is correct; if not, the bearings must be scraped until the mandrel D is in line.

The transverse horizontal alignment of the mandrel D should be absolutely perfect, as very little, if any, change can be made after the off-side bearing d (Figure 45) has been babbitted.

When the mandrel D (Figure 45) has been correctly aligned, the bearing d can be poured, after which both bearings should be scraped to fit the man-

drel until it can be turned easily by hand when both bearings are tightened up.

When the number of engines to be built will war-

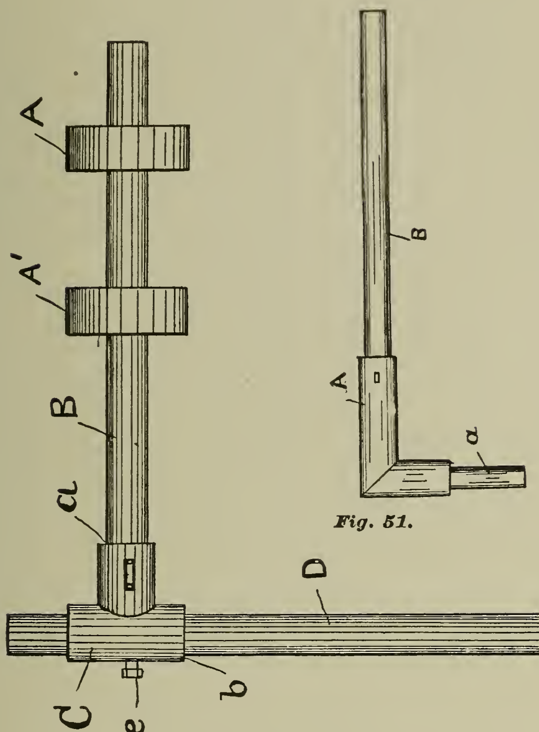


Fig. 51.

Fig. 50.

rant the cost of more expensive appliances for locating and babbitting the crank-shaft boxes or bearings, the jig shown in Figure 49 is certainly the most simple, accurate, and expeditious of any which has ever been devised for the purpose.

The device which is shown in position in Figure 49 and detached in the plan view (Figure 50) consists of two rings or bushings A A′ turned (when the guides are bored) to fit the guides, and bored to fit the shaft B, a casting C bored at a to fit the shaft B (to which it is keyed), and bored also at b at right angles to the bore a to fit the babbitting mandrel D (which is, if preferred, held in the desired position by the set screw e).

When preferred an L casting A (Figure 51) (in which the part a is turned to the size of the crank-shaft journal) may be used on the end of the shaft B for babbitting the near-side bearing c (Figure 49) of the crank shaft, locating and babbitting the off-side bearing d by means of the mandrel D (Figure 45), as already explained.

The arrangement for locating the jig may be changed to suit the requirements or preferences in any particular case as follows:

First. In place of the ring or bushing A (Figures 49 and 50) the end of the shaft B may be made to fit into the gland or stuffing box of the cylinder head, or if the shaft B is smaller than the hole in the gland box, a bushing may be made to fit onto the end of the shaft and into the hole of the gland box, thereby affording an opportunity for gauging the distance from the center of the crank shaft to the center of the guides or cylinder.

Second. To continue the shaft B through the gland box into the cylinder and substitute a ring or bushing which fits the bore of the cylinder for the ring A (Figures 49 and 50).

In using this jig, place it in position, as shown in Figure 49, then gauge the distance from the center of the mandrel D to the center of the guides or cylinder, and then level the mandrel D with a spirit level to obtain the horizontal alignment of the same. By

this arrangement either one or both of the bearings for the crank shaft may be poured as preferred, but usually the near-side bearing is poured (babbitted) first and then the mandrel D is extended to reach across the boiler, and the off-side bearing d fitted too and babbitted thereon. The jig can then be removed and the bearings scraped to fit the mandrel D (as hereinbefore explained), or reamed to size, as desired.

When the bearings are reamed to size (instead of being scraped to fit the crank shaft or mandrel D, as above) a shell reamer, such as shown in Figure 52, is used, where A represents the shell reamer, which is bored to fit the guide bar B, and slotted on the end at E to engage with the driving pin E′ on the guide bar B.

Figure 53 shows the reamer in operation (with the bearings c d partly in section). Two guide rings or bushings C C′ are placed in the bearing c to guide and steady the guide bar B while the bearing d is being reamed.

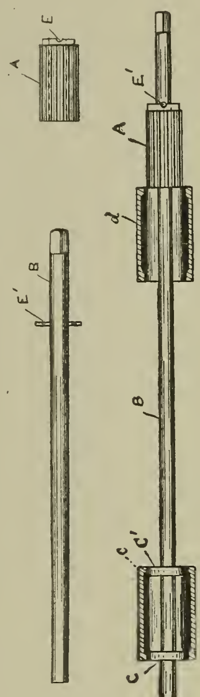


Fig. 52. *Fig. 53.*

The guide rings C C′ are then transferred to the bearing d and the reamer to the bearing c and the operation repeated.

If the reamer is properly made, a very smooth and true bearing can be made in this manner.

Having finished the bearings for the crank shaft, the fitting of the traction mechanism should be pro-

ceeded with before the assembling together of the other parts of the engine.

In considering the various methods which are and may be successfully employed for locating and aligning the shafts, etc., of the propelling mechanism of a traction engine we shall of necessity be compelled to confine ourselves to the consideration of one particular type of engine, but in doing so, the type of engine selected is one which embodies in its construction all the well-known movements used on many types of traction engines, and therefore any appliance which is adapted to this type of engine can be readily adapted to accomplish the same purpose on any other type of engine.

In illustrating the above appliances such parts only of the boiler and attachments will be shown as are absolutely necessary to an intelligent understanding of the devices and methods employed.

In the type of engine selected for consideration the traction mechanism consists of a main axle for the road wheels and an over-shaft for the reducing gears. The differential and other gearing upon these two shafts is driven from the crank shaft by means of a side-shaft and bevel gears. The whole of this mechanism (with the exception of the side-shaft mentioned above) is located on the rear of the boiler, is mounted on springs, and fixed to and held in position by four (two on each side) vertical slide bars or rods which pass through the axle and over-shaft boxes and also through four (two on each side) corner (guide) brackets (which are bolted to the corners of the boiler) in which the slide bars are free to move up and down and by which they (the slide bars) are held in position. These guide, or as they are termed, "corner brackets" are located and aligned by means of a jig, Figure 54 showing end elevation, and Figure 55 plan view of the jig in position

on the boiler. The jig consists of a plate A A′ and two arms B B′ into which are fixed eight vertical pins (the inner ones marked g and the outer ones marked g′) which on the jig represent the vertical slide bars mentioned above.

The jig plate A A′ is first set on the rear end of the boiler, in a true vertical position, plumbing it

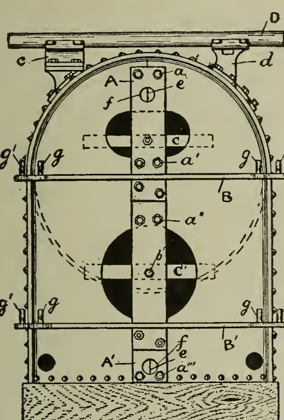


Fig. 54.

Fig. 55.

from the sides and back, centering it from the vertical center line e e (on the boiler) to lines drawn along the bottom of the sight holes f f, adjusting the plate by screwing the set screws a a′ a″ a‴ (only those on one side of the plate being marked) in or out until each one just touches the boiler and there is no rock to the plate. The plate is held in position by the bolts b b′ and the cross plates c c′. The arms B B′ are then placed and bolted in position on the plate A A′ and aligned transversely by tramming from the center on each end of the mandrel D (in the crank-

shaft bearings) to the centers of the outside vertical pins g′ g′ on the arm B, the adjustment being made

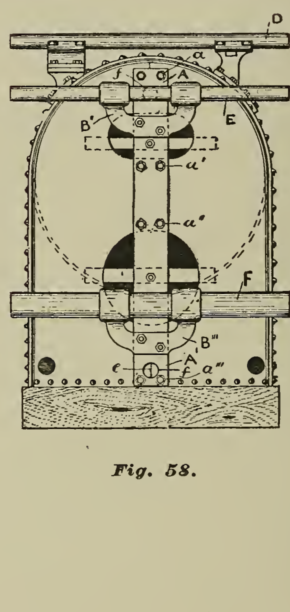


Fig. 58.

Fig. 56. *Fig. 57.*

by screwing the whole of the set screws on the right or left side of the plate A A′ in or out as required. The corner brackets are then fitted onto the vertical pins g g′ and also fitted closely to the side and back

of the boiler shell, to which they are bolted, and the space between the boiler shell and the bracket filled with molten spelter.

The locating and aligning of the main axle and over-shaft (and their boxes) may be effected either with or without jigs or other special appliances.

When no jig or other special appliance is used the boxes are fitted directly to the axle and shaft with the vertical slide bars in position, using a spirit level for the horizontal alignment, and tramming from the centers of the mandrel D (in the crank-shaft bearings) to the centers of the axle and over-shaft, for the transverse alignment, using a pair of ordinary extension trams for this purpose when nothing better is available. But whenever possible the bow trams shown in Figures 56 and 57 are preferable, the construction of these being such that no perceptible difference can occur in the distance between the tram points, owing to the sag of the tram bar, or the way in which the trams are held by the operator, such as frequently occurs when using trams of ordinary construction.

When the axle and over-shaft have been correctly aligned, the boxes are prepared for and then babbitted, first securing them firmly in position on the vertical slide bars, in order that the alignment of the axle or shaft may not be impaired or the shafts cramped in the bearings when this is subsequently done.

When jigs are employed for locating the axle, over-shaft, and their boxes, the jigs may be located either directly from the mandrel D or on the rear end of the boiler. In the latter case, this can be effected by removing the arms B B′ from the jig plate A A′ (Figures 54 and 55) and then bolting the arms B″ B‴, Figure 58, in position on the jig

plate in the place thereof. As the jig plate A A′ has already been aligned vertically (and as near as practicable transversely also) it will only be necessary to test the jig for the transverse alignment by tramming from the centers of the mandrel D to those of the mandrels E and F to be sure that they are correct. In fitting and babbitting the axle and over-shaft boxes, the vertical slide

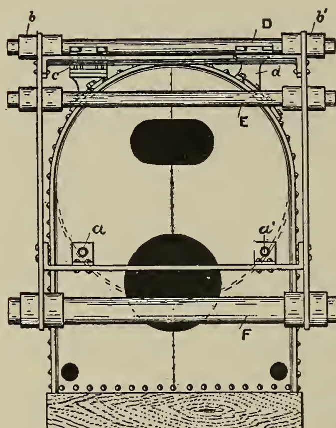


Fig. 59.

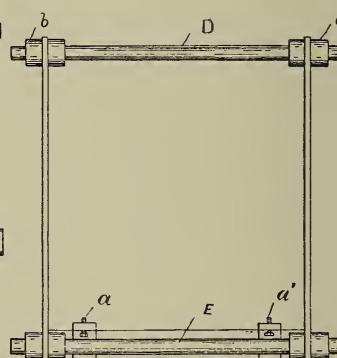


Fig. 60.

bars should be in position all the time, and the position of the mandrels E and F on the jig plate A A′ should be the same as the axle and over-shaft would be. When the jig is as in this case located on the rear of the boiler, the distance between the crank shaft and the mandrels E and F is to a certain extent immaterial. But when the jig is located directly from the mandrel D the distance from the crank shaft to the rear of the boiler should be regulated accordingly. Figures 59, 60 and 61 represent end and side

elevation and plan view respectively of a jig for locating the mandrels E and F direct from the mandrel D (crank shaft). By this arrangement the necessity of testing the correctness of the alignment of the mandrels E and F is obviated. It is only necessary to place the jig in position and then slide the mandrel D through the hubs b b′ and the jig is located, adjusting the distance of the mandrels E and F from the

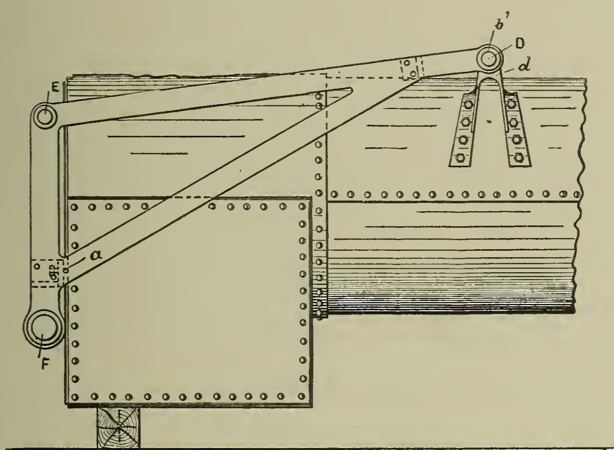


Fig. 61.

rear of the boiler by means of the set screws a a′. With either form of jig the mandrels E and F may be pushed in or out to facilitate the operation of fitting the boxes as required.

Figure 62 shows a plan view of a jig for locating the side shaft G for driving the traction (propelling) mechanism (of which mention has already been made). This shaft runs in a longitudinal direction, parallel to the axis of the boiler from the off-side bearing d of the crank shaft D to the right-hand box

d′ of the over-shaft E and at right angles to both, the bearings for the side-shaft G spanning the bearing d and the box d′ in the spaces e e′, upon which they swing to allow for the up and down motion of the traction mechanism when the engine is on the road. The bearings for the side-shaft are fitted over the bearing and box d d′ at e e′ and then to the mandrel G at f f′, upon which they are babbitted.

The bearings for all the shafts having been fitted

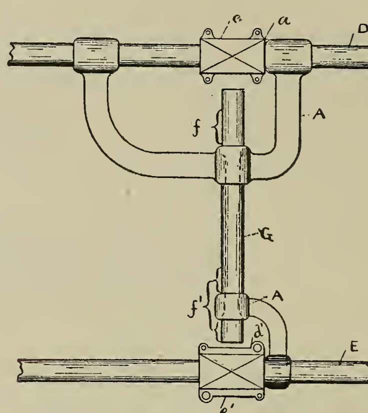


Fig. 62.

and babbitted, it only remains then to remove the jigs and mandrels and assemble the various parts of the engine (which have usually been previously fitted ready for assembling by the vise and machine hands) together.

The locating and babbitting mandrels which have been shown in connection with the above jigs may be dispensed with altogether, and the shafts, which form part of the mechanism, used in the place thereof, if desired, adapting the jigs to suit the shafts

instead of the mandrels. Another change which may be necessary is to make the hubs by which the jigs and mandrels are located and aligned in the form of split boxes or bearings to facilitate the application and removal of the jig to and from the crank shaft, and of the other shafts to and from the jig.

The principle and construction of the foregoing jigs are such that these or a modification of some of these to adapt them to each particular case are applicable to any and every type of portable, skid or traction engine, and though but one type of engine has for convenience been employed in describing the construction and application of these jigs, the various forms shown for securing the same ends are such as have been and can be adapted to a wider range of machine and constructive work.

CHAPTER VIII.

ERECTING.—*Continued.*

ERECTING AS APPLIED TO STATIONARY ENGINE WORK.

Having already shown many of the principles and methods employed in constructive mechanics as applied to erecting, we can now proceed to the further consideration and development of these same principles and methods as adapted and applied to and in the construction of a higher grade of work.

And in giving examples of the processes employed in the laying out and erecting of work of a higher order, it is thought best to let the work be of the various types and parts of stationary engines, and to let the types and parts selected be such as will represent, not engines alone, but a wider range of machine work.

In the erection of horizontal engines we have to consider the following requirements:

First. That the axes of all reciprocating and revolving parts must bear a fixed relation to those of the cylinder and crank shaft.

Second. That the axis of the crank shaft should always be at right angles with the intersecting axis of the cylinder and guides.

As the bed-plates of stationary engines are liable to be somewhat out of true through warpage or shrinkage in casting, it is imperatively necessary that a line should be drawn (stretched) through the (imaginary) axis of the cylinder and guides, to or beyond the center of the crank-shaft bearings, and that all surfaces that are to be machined

or cut to size should be measured and laid off from the above center line before any machine or other work is done upon the bed, to ascertain if there is a sufficiency of metal upon all surfaces to admit of each surface being cleaned or trued up to size.

Should there prove to be a deficiency of metal on any particular surface or part, the position of the center line should be changed (if possible) to so conform with the laying out of the work as to favor the faulty surface or part sufficiently to admit of its being cleaned or trued up to size. In laying out (sometimes termed lining or marking out) work of any kind it is always good practice to so lay out the work that every part of the same can be trued (cleaned) up to size, throwing the whole of the rest of the lines towards the faulty spot or place if necessary, regardless of how much or how little may have to come off any other part, so long as all can be trued up.

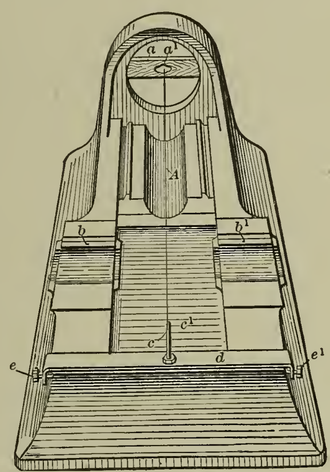


Fig. 63.

Figure 63 shows a plan view of a center crank-engine bed and method of laying the same out ready for the planing. To determine the position of the center line, fit a piece of wood into the hole in the front of the bed at a; the center of the hole or of the projection (on the extreme front of the bed) is then obtained, a hole about $\frac{3}{8}$ inch is drilled through the wood, as shown at a′; this hole is then covered on the outside with a tin

center-piece (which is merely a piece of tin cut square or oblong and large enough to cover the hole, the corners of which are bent so that they can be pressed into the wood to hold the center-piece in position). The center of the hole or projection is then laid off on the tin and a small hole drilled through the same exactly in the center with a scratch awl (scriber) or file tang, the point of which has been ground square; this hole should be drilled just large enough to admit of the center line (cord) being passed through it. The center points b b′ are then laid off in the crank-shaft bearings, and an adjustable center post c is attached to the bed by means of the cross-bar d; a radial slit is then cut through the top of the post at c′ just wide enough to allow of the center line (or cord) being inserted therein. The center line is then passed through the hole a′ and a knot tied on the line to prevent it being drawn too far through the hole; the line is then stretched taught and inserted in the slit c′; a knot is tied on this end of the line also, close to the post to hold the line in position. The insertion of the line through the hole a′ ensures the exact alignment of the same in that end of the bed. The line is centered on the back or crank end of the bed by means of a pair of hermophrodite calipers, or with either of the wire trams shown in Figure 64, tramming from the center points b b′ to the line for the longitudinal or lateral alignment, and for the horizontal alignment, measuring the height of the center a′ (the engine bed resting on a platen or other level surface) by means of a surface gauge, and then making the height of the line the same at c′ as at a′, raising or lowering the center post c by screwing it out of, or into the cross-bar d, as required.

The object of drawing the center line through the bed as shown above is twofold:

First. To ascertain if there is sufficient stock

(metal) on the guides and all other parts that are to be planed or otherwise cut to size, and

Second. That the center line may be used as a point from which the measurements can be made in planing up the guides, the ends of the crank-shaft bearings, and any other parts that are to be planed, faced, or bored, and it is also utilized in setting, on the planer or other machines. When for any reason it is necessary to remove the center line before it is finally

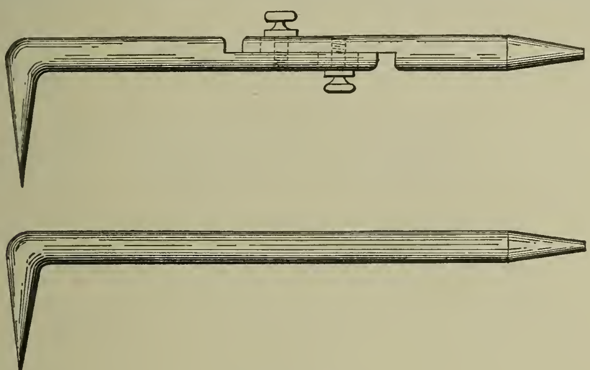


Fig. 64.

dispensed with, it can be readily slipped out of the slit c′ without disturbing the post c, and afterwards when it is reinserted in the slit it is in line again without any resetting.

In many engines of this class the lower guides are either cast on and form a part of the bed, or else the guides are separate pieces resting upon planed surfaces on the bed.

In either case these surfaces are planed to a definite distance below or above the center line (or axes of the cylinder and crank shaft). Such being the case, when the planing has been done on the bed, the guides (or the planed surface upon which the guides rest) can and should always be utilized as a base for locating

and aligning the jigs and other appliances used for babbitting or boring and facing the bearings and other parts of the bed.

When engines are built in quantities, a platen or bed-plate of suitable size, mounted on a good foundation, should be placed on the erecting floor, or a separate bed-plate or platen which can be moved whenever required should be provided for the use of the erector to facilitate the various operations on the engine beds.

One of the least expensive appliances employed for holding and aligning the babbitting mandrel or

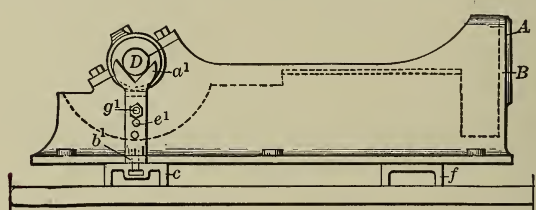


Fig. 65.

crank shaft while the bearings for the latter are being fitted and babbitted is shown in Figures 65 and 66, which represent a side and end elevation of the device in position ready for babbitting the bearings; D is the babbitting mandrel, a b and a′ b′ adjustable V brackets mounted on a slotted parallel c which is placed under the engine bed in line with the center of the bearings, f (Figure 65) shows end view of plain parallel which pairs with the parallel c. The transverse alignment of the mandrel D is obtained by squaring from the guides (after the guides are planed), or by placing a straight edge across the face of the projection A (Figure 65) (after the latter has been faced or turned), and then tramming from the

straight edge to the mandrel. When the device is to be used on a larger-sized engine bed, the bolts g g′ are taken out and the V plates a a′ raised as much as required by inserting the bolts g g′ in some other of the holes (shown by dotted lines at e e′).

The projection A and the bore B (shown by dotted lines) (Figure 65) are faced or turned off and bored to receive the back cylinder head and the cylinder, as will be hereinafter explained.

Though the above device is inexpensive to make and can by spacing the holes e e′ correctly (or by

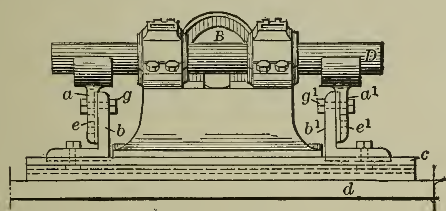


Fig. 66.

substituting longer plates for the V plates a a′) be used for the purpose stated for several sizes of engine beds, it is not self-aligning, and for that reason is not as good for the purpose as other devices which are self-aligning.

As already stated, the guides can be used as a base from which all the jigs and other appliances (employed in the various operations on the engine bed) may be located and self-aligned.

Figure 67 shows method of locating and aligning the mandrel for babbitting the crank-shaft bearings of a center crank engine (using the same reference letters to designate the same parts, as hereinbefore employed in Figures 49 and 50). A A′ represents the guide blocks, planed to fit the guides, and held in

place by the bolts for the upper guide bars, or otherwise held in place by straps and bolts (when the holes for the guide-bar bolts have not as yet been drilled). Instead of aligning the mandrel D horizontally by means of a spirit level, it is self-aligned by means of a key or feather fitted in one or both of the guide blocks A A′, and a key-way cut in the guide shaft B.

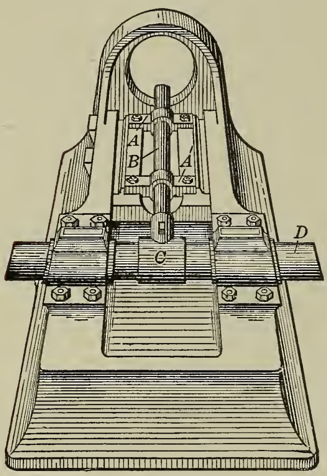


Fig. 67.

If the diameter of the guide shaft B is made as large as can be consistently employed between the guides of a small-sized engine bed, and the size and bore of the T casting C is made large enough to take in the mandrel D for a larger (or the largest) size of engine bed, this appliance can be used on several (if not all) of the different sizes of engines made in the shop, by using bushings to reduce the size of the bore of the T casting C to that of the babbitting mandrel D, and by having a pair of the guide blocks A A′ for each size of engine bed, or by making one pair of guide blocks do for two sizes of engine beds, as shown in Figure 68 which represents an end view of the guide blocks A A′ as made for two sizes of engines, by planing the lower half a of the block (below the center line b) to fit the guides of a small-sized engine bed, and the upper half c of the block to fit in the guides of the next (larger) sized engine bed.

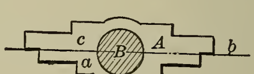


Fig. 68.

Of course it will be understood that a separate babbitting mandrel D will be required for each size of engine bed or crank shaft.

Another form of jig for locating the babbitting mandrel D is shown in position on the engine bed in Figure 69. The jig as therein shown consists of one casting, planed to fit the guides, and extending to

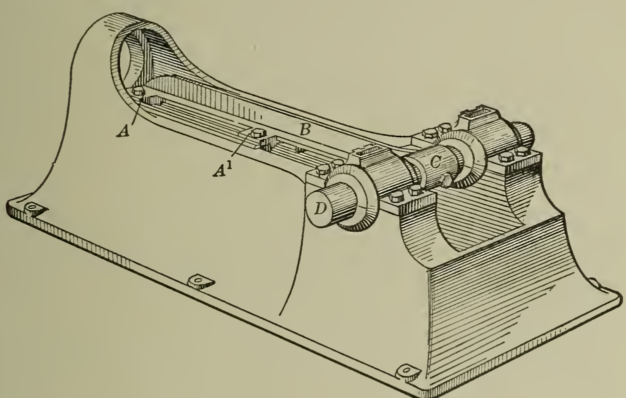


Fig. 69.

the crank-shaft bearings, where it terminates in the form of a hub. The cross-plates A A′ and the extension plate or arm B and hub C are equivalent in this instance to the guide blocks A A′, guide shaft B, and hub C of Figure 67.

This is an excellent device, is self locating and aligning, and fills the requirements in every particular, but as it is necessary when this form of jig is employed to make a separate jig for each size of engine bed, it therefore lacks the advantage possessed by the jig shown in Figure 67, of being applicable to more than one size of engine bed.

In a large proportion of horizontal and vertical

stationary engines, the valve stem (rod) is connected to a slide attached to the side of the engine bed, the slide being operated direct from the eccentrics. In order that all the eccentric and valve connections can be made interchangeable, the position and alignment of the slide must be exact. To expediate the fitting and babbitting (if the bearings are lined with babbitt) of the slide and bearings for the same, the jig E and mandrel F, shown in Figure 70, are employed. The jig, as shown therein, is located and held in position on the guide shaft B by means of the hubs a a′ and arms b b′ which extend over the side of the bed to locate and hold the mandrel F while the bearings c c′ are fitted and babbitted. In other cases the jigs are located directly on the guide or guides.

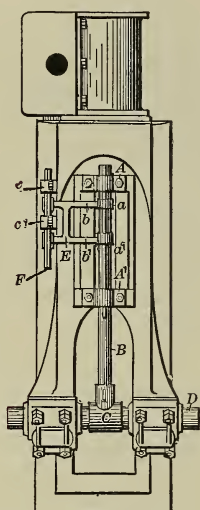


Fig. 70.

Similar jigs may be used for the rocker arms or shafts, when rockers are employed for actuating the valve and connections for the same.

In nearly all engines of this class the cylinder is bolted on the front end of the engine bed. The back cylinder head is fitted into the bored recess B (Figures 65 and 66) of the engine bed, and fitted into the cylinder in the usual way, the studs in the back end of the cylinder passing through the cylinder head and projection of the engine bed, the whole being held together by the nuts on the inside of the bed.

The boring and facing of the projection on the front of the bed is usually done on a special boring machine; and though this operation does not in

general practice come within the province of the erector, still there are many instances where the

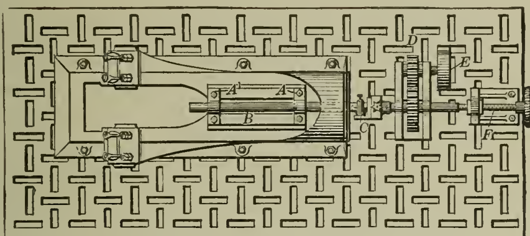


Fig. 71.

erector has to do all the work required on the bed except the planing. In such cases, if the boring and facing is not done on the boring machine, or on a large lathe, some special device termed a "boring rig" is employed for this purpose. The boring rig shown in Figure 71 was designed for work of this description and can be employed for boring and facing heavy work in almost any position.

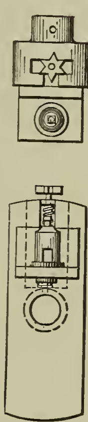


Fig. 72.

In the figure the boring rig is shown in position ready for facing or turning off the projection on the front of the bed, and consists of a boring bar B, which is located and guided by the guide blocks A A′, a sliding tool post C (of which an end and front elevation is shown in Figure 72), the driving mechanism D, and pulley E, and a feed screw and bracket F, the boring rig, together with the bed, being fixed on the erecting platen. In facing off the front of the bed the tool is fed across the work by a star feed,

and, in boring, the tool is fed through the work by the screw feed F.

When the boring and facing of the front end of the bed is completed, the boring bar should be withdrawn and the bed, if a small one, should be swung around on the platen and the crank-shaft bearings brought into line with the boring bar to bore out the bearings; but if the bed is a large one, instead of turning the bed on the platen, the boring bar and attachments should be fixed transversely across the platen and brought into line to bore out the bearings. Where any of the preceding babbitting appliances have been used for babbitting the bearings, the boring rig, as shown in position in Figure 73, ready for bor-

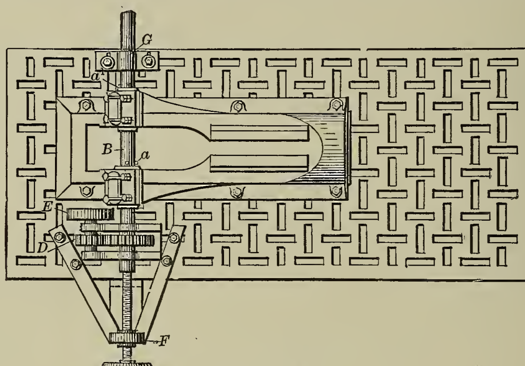


Fig. 73.

ing the bearings, can be aligned transversely by means of the jig in the same manner as the babbitting mandrel or the boring bar can be transversely aligned by squaring from the guides, or by placing a straight edge across the faced projection on the front of the bed, and then tramming from the straight edge to the boring bar.

An additional bracket is required at G to support and guide the boring bar (in place of the blocks A A′

used when boring and facing the projection on the front of the bed), and an extension bracket F takes the place of the bracket F of Figure 71. The boring tools are shown at a a′ ready for starting a cut through the bearings. When the bearings are lined with babbitt (babbitted) the babbitt lining should be hammered well down (with the peen of a hammer) to the boxes all around, or in lieu thereof a roller tool, such as shown in Figure 74, should be inserted in the bar in the place of the boring tools a a′; the roller is then set out, to describe a circle about 1-16 inch larger than the bore of the bearings (in the rough); and when the roller is fed through the bearings, the babbitt-metal will be compressed and the bore enlarged to an amount equal to whatever the roller has been set out. The bearings are then bored out, and the ends of the boxes faced off, if preferred, by means of the boring bar instead of planing them off.

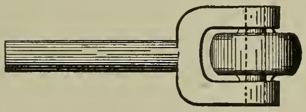


Fig. 74.

By placing parallels of suitable size under the smaller-sized engine beds, and making the height of the boring bar (and rig) suitable for the largest-sized engine bed, this boring rig can be used for doing all the boring and facing that has to be done on every size of engine bed made in the shop.

The boring rig is driven in both positions by a belt from a counter-shaft placed lengthwise of, and above the platen in such a manner that when boring the bearings the belt is crossed, and when boring and facing the projection on the front of the bed the belt runs straight. The pulley on the counter-shaft is movable as necessitated by the adjustment required for the various sizes of engine beds.

If a flexible shaft is available, it is much better

than a belt for driving the boring rig, and it can also be used for doing all the drilling required on the beds. The counter-shaft can also be used for driving the drilling attachment if a round belt is employed, and provision is made (by means of weighted idler pulleys) for shortening or lengthening the belt as required.

On vertical engine work, the horizontal and transverse alignment of the crank shaft is always at right angles to the planed surfaces of the valve seat and steam chest, and to get the alignment of the crank shaft exact without special tools or appliances is a job requiring considerable patience and mechanical ability. The ordinary method of doing this is to put a pulley or disc on the mandrel used for babbitting the bearings (when the bearings are babbitt lined) or on the crank shaft (when the bearings are babbitted directly on the crank shaft), and then to hold a straight edge across the rim of the pulley or disc, and another straight edge transversely across the valve seat or planed edges of the steam chest, then to sight from the upper to the lower straight edge, twisting the mandrel or crank shaft in either direction until the lower straight edge is in line with the upper straight edge. In other cases where the cylinder is a separate casting, bolted on the top of the frame, the crank-shaft bearings may be aligned and bored first, and the cylinder and steam chest located from the crank shaft by means of straight edges, etc., as explained above.

For locating the babbitting mandrel first the V brackets shown in Figures 65 and 66 may be employed, provided they are mounted on a suitable platen or base plate.

A modification of the babbitting jig shown in Figure 67 to adapt it to the vertical style of engines, makes it the most efficient appliance that can be em-

ployed for this purpose, securing at once the perfect alignment of the mandrel D in all directions.

Figure 75 shows the jig in position as adapted and applied to a vertical engine (similar reference letters denoting the same parts as heretofore); the guide ring A′ (shown partly by dotted lines) is made to fit the counterbore on top of cylinder, thereby serving two purposes, namely, to determine the distance from the axis of the crank-shaft to the center of the cylinder and guides, and to assist in locating the guide shaft B (to which it is held by a key or nut) concentric with the cylinder and guides when the guides are bored, a guide block fitted to the guides in place of the guide ring A serving the same purpose when other forms of guides are employed. The mandrel D is aligned transversely by means of an arm E and a bracket H. The hub F of the arm is keyed to the guide shaft B and a cross-plate G is fitted on the other end of the arm on the same transverse line as the valve seat and bracket H. The bracket H is bolted to the planed edges of the steam chest or to the valve seat itself. As there may be a slight variation in the distance from the center of the cylinder to the valve seat or the planed edges of the steam chest, on different

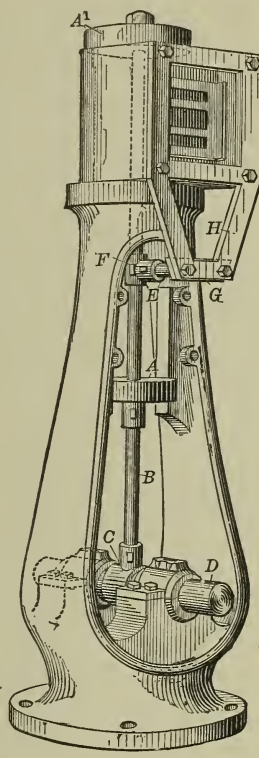


Fig. 75.

engines the cross-plate G is made adjustable on the arm E to compensate for any variation that may exist.

CHAPTER IX.

Erecting.—*Continued.*

DRIFT PIN AND DRIFT WEDGE FOR REMOVING PISTON RODS FROM THE CROSS-HEADS.

Figure 76 represents a strap, drift pin, and drift wedge employed for driving cross-heads and piston rods apart in those cases where the piston rod terminates in the form of a taper shank inserted in the taper bore of the cross-head, both being held together by a

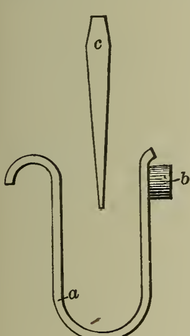


Fig. 76.

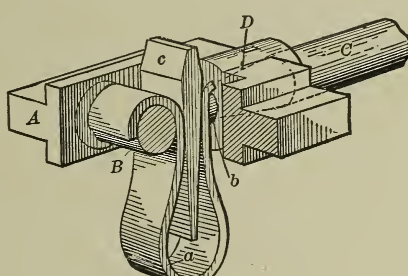


Fig. 77.

taper key driven through the cross-head and rod. This form of connection is almost exclusively employed in locomotive practice, and to some extent on stationary engine work also.

As shown in the side view (Figure 76), the device

consists of a strap a to which the drift pin b is welded, and a drift wedge c.

Figure 77 shows the cross-head (partly in section) and piston rod, with the strap and drift wedge in position thereon, A representing the cross-head, B cross-head pin, C piston rod, D taper shank of the same, a strap, b drift pin, c drift wedge. The strap a serves to hold the drift pin b in position against the end of the taper shank D, and it also serves to protect the cross-head pin B when driving the wedge c. This device is simple, easy to make, and when the drift wedge is not given too much taper is as efficient as any employed for this purpose.

BALANCING PULLEYS AND ROTARY PARTS OF MACHINERY.

Pulleys are usually balanced upon an arbor inserted in the bore of the pulley after it has been bored and turned. The pulley and arbor are then placed on balancing ways which are either improvised for the occasion, or specially constructed for the purpose. In either case the balancing ways are first leveled separately, then together, and then when the arbor and pulley are placed upon the ways, the heavy side or part of the pulley will cause it to turn on the ways until the heavy side is on the bottom. Strips or plates of iron, equal in weight to whatever the pulley is out of balance, are then riveted or screwed to the inside of the pulley, diametrically opposite the heavy place. It does not necessarily follow though, that when a pulley is apparently in perfect standing balance it will be the same when running, for it may be out of balance considerably when running. Sometimes this can be remedied by putting the balancing strip or plate in the same relative position on the inside of the pulley, but on the opposite side of the

arms; at other times it may be necessary to change the position or weight of the balancing piece altogether, in order to get a perfect running balance.

It frequently happens that a pulley is apparently in perfect balance, both standing and running, while it is being balanced, but when it is placed in position on the line or other shaft it will wabble and act as though it had never been balanced at all. The cause of this lies in the fact that the pulley really is somewhat out of balance, but to such a slight degree that when running singly it is not perceptible; but if it happens that the pulley is placed on the shaft alongside or in the proximity of one or more pulleys that are out of balance to a similar extent, the aggregated amount that both or the whole of the pulleys are out of balance will, when the heaviest parts are all in one line, produce a noticeable effect, which can only be remedied by turning one or more pulleys on the shaft, whereby one unbalanced pulley is made to counterbalance the other. When there is only one or a few pulleys to be balanced, the balancing ways may be improvised for the occasion by placing long narrow parallels, such as are used on the planing machine, upon a pair of wooden trestles (horses), and then leveling them together, and separately, then balancing the pulley thereon, as already explained. When there are many pulleys to be balanced, special balancing ways made for this purpose should be used. One form of these, shown in Figure 78, consists of a cross-bar A (planed parallel on the top and slightly beveled on the sides) and three legs B B′ B″ with thumb screws C C′ C″ in the feet to level the balancing ways by. This form of balancing ways are as good as any with which we are acquainted; they are easy to make, and can be set and adjusted anywhere in a few minutes.

Armatures, cylinders, or beater drums for threshing

machines, and all similar rotating parts of machinery are first balanced on the balancing ways (in the manner explained) and afterward balanced for the running balance, either in the frame of the machine of which it forms a part, or in a balancing frame specially constructed for the purpose. The latter frame is usually made of wood of a size suitable to take in the work to be balanced, or is made adjustable to take in

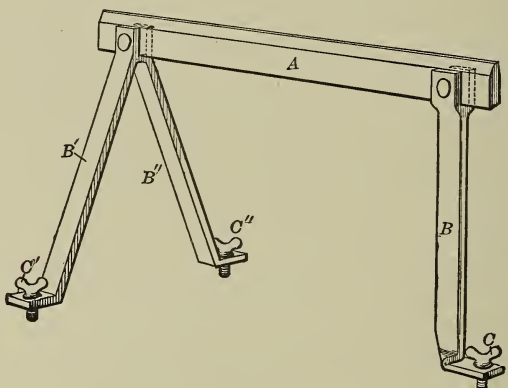


Fig. 78.

work of different sizes, and the bearings are either made the right size for the journals of the work, or are made V shaped to take in work of any size. The work is placed in the balancing frame, and after putting a pulley and belt on, it is gradually speeded and balanced until it will run smoothly at a velocity which exceeds that at which it is intended to be run by from three to five per cent. When first starting to run and balance the work, the upper half of the bearings are left on, but before the work is said to be in perfect balance the upper half of the bearings are left off altogether, and the work run at full speed without any other support than the lower half of the bearings.

Having shown the methods employed for locating and aligning the different parts of machinery in almost every conceivable position during the fitting and erecting of the same, it only remains for the author to add that in these days of close competition it is absolutely necessary that every available appliance which can be used to expediate, facilitate, and reduce the cost in the manufacture of machinery of every description should be adopted and employed to that end. Want of space will not admit of our giving more extended examples of the application of special appliances employed in the erecting of many other kinds of machinery, nor would it be advisable to do so, as it would, to a certain extent, only be a repetition of what has already been shown. As, for instance, the jigs and appliances for boring the hubs (bearings) in which the various shafts of the driving mechanism of a planing machine run are located in the V's of the planer bed, and are so arranged that the position of each shaft is definitely determined. The position of the feed rods and screws is determined in the same way by jigging from the slides of the cross-rail.

And on lathe work the position of each part of the feed and screw cutting mechanism in the carriage and apron attached thereto is determined by jigs fitted into the shear V's of the carriage or directly upon the apron itself, and the bearings for the spindles in the head and tail stock are bored in perfect alignment by means of special jigs or fixtures placed on the shears of the lathe bed, at each end of the head or tail stock; or, what amounts to the same thing, boring the head and tail stock on a machine having a supplementary platen attached thereon with shears which are an exact duplicate of the lathe shears. In this manner any machine and all the parts thereof can be made strictly interchangeable, and by selecting the principal shafts or planed surfaces of a machine or part as a

basis a jig or other appliance can be attached thereon in such a manner as to serve any purpose desired.

On certain kinds of work it may happen that there is no shaft or surface to which a jig or other appliance can be affixed, or that, when such do exist, the shaft or surface is insufficient to serve as a base for the attachment of the jig, and in other instances it may be possible to arrange the jig to better advantage or to extend its usefulness by making it to assist in or cover other operations on the work by casting separate lugs, bars, or depressions on the work for the attachment of the jig or appliance. In some cases these lugs or bars are left on the work for future reference or use, but as a rule they are broken or cut off after they have served their purpose.

Then again there are instances where the work can be operated on to better advantage by inclosing the work entirely within the jig or appliance. And so it often happens that when a particular piece of work has to be jigged, etc., that no precedent of a like nature can be found that will serve as a guide in designing and constructing a jig or other appliance for the work, but that a special jig or appliance must be designed and constructed for the purpose required.

CHAPTER X.

Planing, Shaping, Slotting.

PRINCIPLES AND METHODS OF CHUCKING THE WORK.

One of the first and most important considerations in connection with planer work is the methods employed in chucking (holding) the work on the platen or work table, and the principles which should govern these methods. The mere fact of being able to clamp or hold the work securely on the machine while it is being operated on will not suffice in itself; the work should be clamped in such a way as not to cause any strains upon it whatever. It is well understood that the shape of work, and especially of cast-iron work, will sometimes change when a cut has been taken over it to remove the scale on the outer surface, thereby releasing it from any internal strains acquired in casting. And making all due allowance for such being the case, still it has been frequently demonstrated that the work is more often sprung by improper clamping than from any other cause, as fully evidenced by the many practical devices and inventions for equalizing the

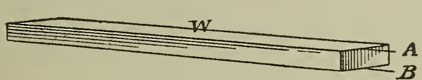


Fig. 79.

work in clamping fixtures while it is being operated on. To illustrate this more fully, let it be supposed that the bar W (Figure 79) has to be planed on the

surfaces A B, and as we only wish to show the effect produced on the work by improper clamping, we shall disregard the ordinary and special forms of chucks employed for holding such work, and clamp the work (bar) directly to the platen. Figure 80, represents a side view of the work clamped on the ends to the platen; A A′ the bolts and plates by

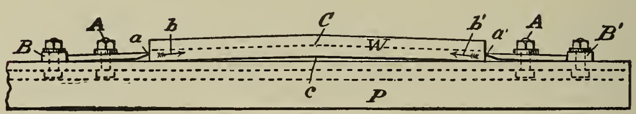


Fig. 80.

which the work is held, B B′ stops to brace the latter, W work, P platen.

If the work is clamped so that the points a a′ of the plates bear on the work below the median line C (shown by dotted lines), the result is that the work may be sprung in the direction indicated by the arrows b b′ sufficiently to raise the work from the platen at c to an appreciable extent, and consequently when the pressure of the clamp is relieved after the planing, the surface of the work will be hollow to whatever extent the work was sprung in clamping. Then, if on reversing the work to plane the opposite side the same improper method of clamping is followed, the result will be that, when the work is finished (planed), it will be thinner in the center than on the ends. But if, on the other hand, the pressure on the ends of the work is applied at the points a a′, above the median line C, as shown in Figure 81, the result will be that the work is firmly bedded on the platen throughout its entire length, the strains, if any, being in the direction indicated by the arrows b b′, and the tendency to bed the work on the under

side (in the middle of its length) at c before it is bedded on the ends, and consequently the work will be perfectly true in nearly every instance.

Another practical application of this same principle is shown in Figure 82, which represents an improved

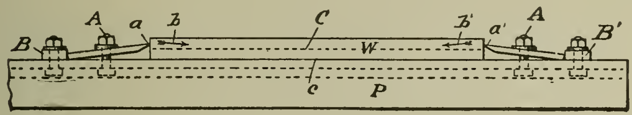


Fig. 81.

method of chucking thin work in the planer or shaper chuck. As therein shown, the work W is held in the chuck A A′ on the top of a parallel B by means of the chucking plates C C′, one end of which is inserted in a groove cut along the inner surface and near the top of each jaw of the chuck at a a′. The pressure being

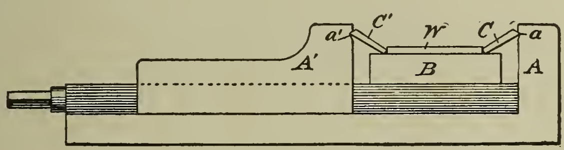


Fig. 82.

applied above the median line of the work prevents it from buckling (as the springing of the work is termed) in the center in the manner shown in Figure 80. The manner of grooving the chuck jaws for the insertion of the chucking plates C C′ and the direction in which the pressure is exerted on the work will be better understood by referring to Figure 83, which represents a partial side view of one end of the chuck and work.

A large variety of work can be chucked in this manner and operated on to much better advantage than when simply held between the jaws of the chuck. With special chucking devices, work of every description can be chucked or held in such a manner that the strains produced in chucking can be equalized, or at least minimized, in all directions.

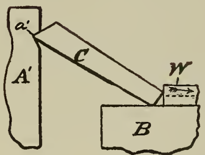


Fig. 83.

The importance of this subject is now so clearly appreciated, that in many of the larger establishments the chucking appliances form a very prominent part of the shop's equipment. And when such chucking appliances are intelligently employed, the necessity of loosening and then rechucking the work after a cut has been taken over it to remove the scale (for the purpose already explained) is always lessened, and in most cases is entirely obviated.

CHAPTER XI.

Planing, Shaping, Slotting.—*Continued.*

CHUCKING TAPER WORK.

There are several ways in which taper work may be chucked. In some forms of chucks one of the jaws is made adjustable and is therefore suited to hold either straight or taper work, but when the jaws of the chuck are not adjustable other means must be employed for holding the work. Take as an example a connecting-rod key. If there is only one key to be planed, the key is laid on a parallel piece of suitable size and the chuck tightened up until it just grips the key on the broad end. A small piece of blocking is then interposed between the jaw of the chuck and

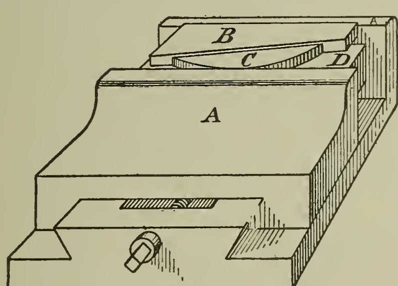


Fig. 84.

the narrow end of the key, and the chuck is tightened up sufficiently to hold the work firmly. When there are two or more keys to be planed they are chucked as parallel pieces by reversing the tapers of the keys.

The method of holding taper work shown in Figure 84 is very simple and may be used for holding

work of any taper. The work is held by means of a semicircular chucking piece interposed between the sliding jaw of the chuck and the work, A A representing the chuck, B the work, C semicircular chucking piece, D parallel placed under the work to act as a support and to align it horizontally.

A similar semicircular chucking piece may be employed for holding taper work in the vise while it is being fitted, and will be found to be as handy as any tool the vise workman possesses.

MONITOR CHUCK.

The monitor chuck shown in Figures 85 and 86 may justly be regarded as the "*ne plus ultra*" of chucking devices, for of all the appliances employed in machine-shop practice there is none more capable

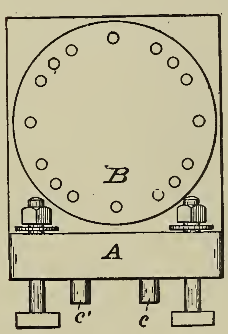


Fig. 85.

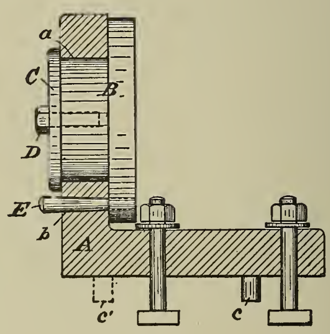


Fig. 86.

of such a wide range of application in the various operations and processes as this is.

Figure 85 represents a front and Figure 86 a side elevation (partly in section) of the chuck. The angle plate A is bored at a to receive the revolving chucking plate B, which is held by the washer C and the binding screw E.

The work is clamped to the chucking plate B in such manner that, on revolving the chucking plate and work, each surface to be operated on can be brought into position in succession for the operation. The angles at which the different parts of the work are presented is predetermined by means of the index pin E, which is inserted in the angle plate A at b and in the index holes of the chucking plate B, the holes in the latter being spaced according to the number and position of the surfaces and parts (on the work) to be operated on.

PLANING CONNECTING-ROD BRASSES AND CROSS-HEADS ON THE MONITOR CHUCK.

The next engraving, Figure 87, shows the method

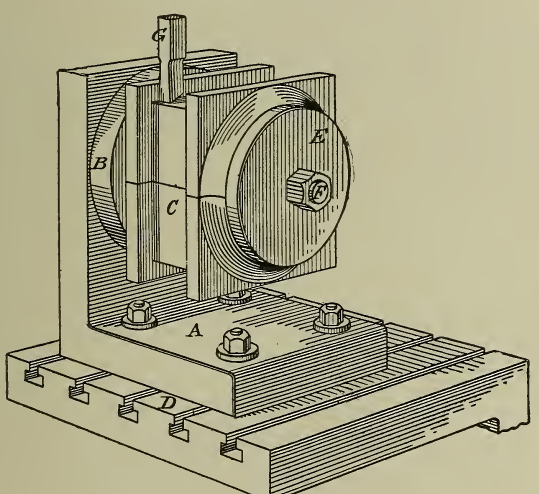


Fig. 87.

of chucking connecting-rod brasses for planing on the monitor chuck A B (Figures 85 and 86), and

shaper platen D. The brasses C are held in place on the revolving plate B by means of the washer E and bolt and nut F. G represents the tool, in position for planing the upper surfaces of the brasses. It will be plainly seen that when the upper surfaces of the brasses have been planed, if the plate B and work are given a quarter turn, the next side of the brasses will be brought into position ready for planing, and so on until the brasses are finished.

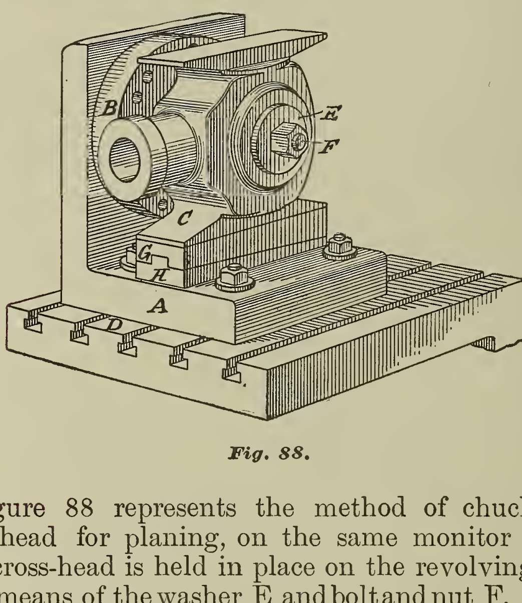


Fig. 88.

Figure 88 represents the method of chucking a cross-head for planing, on the same monitor chuck. The cross-head is held in place on the revolving plate B by means of the washer E and bolt and nut F. It (the cross-head) is also supported and aligned on the under side by means of the adjustable parallels G H. As the method of operating has been described there is no need for repeating it.

CHAPTER XII.

Planing, Shaping, Slotting.—*Continued.*

SUPPLEMENTARY CHUCKING PLATES.

Supplementary chucking plates or work tables are employed to facilitate the operation of planing such work as would otherwise have to be released and re-chucked in order to bring other surfaces of the work into position for the planing when one surface has been finished. The work is chucked or held on the supplementary chucking plate (instead of chucking it on the planer platen) in such manner that as many surfaces as possible may be brought in succession into position for the planing by swiveling or changing the position of the supplementary plate on the platen, instead of resetting the work for each surface.

These supplementary chucking plates are divided into two classes, viz., simple and compound; the simple form consisting of a single plate, and the compound form of two or more plates, the latter sometimes being made in the form of a cross-slide. Both the simple and compound forms can be made square, rectangular, or round, as required or preferred.

As a rule the different surfaces to be planed generally stand on a line with the longitudinal axis of the work, or at right angles to the same, and the methods employed for self-aligning the plate and work when changing the position for the different surfaces to be

planed are threefold, viz., first, by doweling; second, by indexing, and third, by graduating the plates.

Figure 89 shows a perspective view of the under side of a supplementary chucking plate (of the single form) A, and planer platen B B′ (partly in section), with the dowel-pins a b c d passing through the plate from the upper side into the T slots of the platen. As shown in the figure the plate is located in one position at B by doweling into the first and fifth T slots of the platen, and as shown at B′ (by dotted lines), by doweling into the second and fourth T slots for the other position, such an arrangement being rendered necessary when the nature of the work is such that the

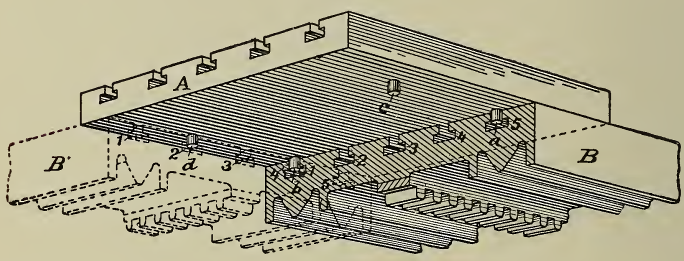


Fig. 89.

dowel-pins would be covered by the work and could not be inserted or removed (if located elsewhere) in changing the position of the plate and work on the platen, or when the plate A is rectangular.

This form of chucking plate, though quite common, is by no means as convenient and reliable as the monitor or round form of chucking plate.

The principal reason for compounding in all forms of these supplementary chucking plates is to supply a means for pivoting the upper plate in the center, and indexing or graduating it on the periphery.

By referring to Figure 90, which represents a (simple) supplementary chucking plate of the round or monitor form, it will be seen that the above features may be embodied in the simple form of chucking plates with the same facility as in the compound

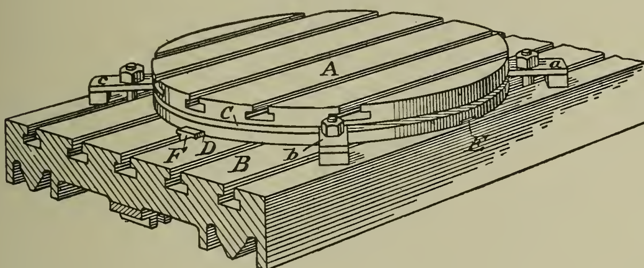


Fig. 90.

forms. This is accomplished by swiveling the plate on a pivot pin located in the center and on the under side of the same in either of two ways, viz., first, by inserting the pivot pin directly in the plate, and

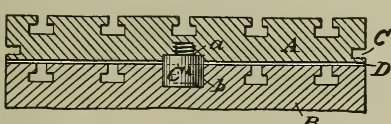


Fig. 91.

drilling the pivot pin-hole in the planer platen, as shown in Figure 91; where A represents the chucking plate (sectional side view cut through the center of plate and platen), B platen, C′ pivot pin, inserted in the chucking plate at a, and in the pin-hole (in the platen) at b. The chief objection to this method of inserting the pivot pin in the plate is that the plate must of necessity always be fixed in the same position on the

planer platen, thereby occasioning excessive wear on some parts of the planer more than on others.

In the second form shown in Figure 92, which

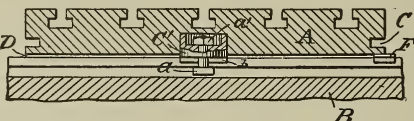


Fig. 92.

represents a sectional side view of the chucking plate A and platen B, with adjustable pivot pin C′, this objection is entirely removed. As shown therein, the adjustable pivot pin C′ is inserted in the center T slot of the platen, and may be located anywhere in the slot. It is held firmly in position in the slot by means of the bolt and nut a a′, the tongue b fitting into the T slot of the platen. The chucking plate is indexed by grooving it on the under side, as shown at D E (Figure 90), in such manner that by bringing one or the other of the grooves into line with the T slot the plate can be located in the position desired and retained in such position by means of the index pin F, which is made preferably T shaped, the smaller diameter fitting the T slot of the platen, and the larger diameter fitting the groove in the plate. The plate is held by means of the bolts and straps a b c, one end of which is inserted in groove C.

PLANING KEY-SEATS IN CRANK SHAFTS.

Referring again to the subject of shaft governors for steam engines, as described in Chapter III, we can now show the methods employed for locating the key-seats (for the governor wheel or disc) in the crank shaft, so that the position of the governing mechanism shall bear a definite relation to that of the crank or crank pin. For convenience in planing, the

position of the key-seat in the crank shaft is always fixed so as to be either in a direct line with the vertical axes of the crank shaft and crank pin (when the crank is either above or below the center of the shaft) or at an angle of 90 degrees to the same. In planing the key-ways, the crank shaft is always chucked or held in the ordinary V chucking blocks, either on the planer platen or on a supplementary chucking plate, which ensures the correct horizontal and longitudinal alignment of the shaft; and as the crank-shaft journals and crank pins are always made on the interchangeable plan, when the first crank is set to the

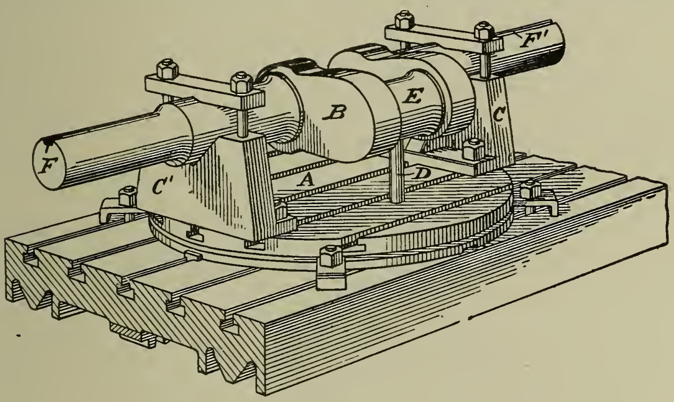


Fig. 93.

correct angle, it is an easy matter to fit a distance piece under or against the crank pin in such manner that it will not only serve to support the weight of the crank pin but will also definitely locate and determine the correct angle at which to cut the key-seats in all the subsequent crank shafts of the same class. When the key-seat is cut at (90 degrees) right angles to the co-axes of the crank shaft and pin, the axes should be set on in the same horizontal line, as shown in Figure 93, where the crank shaft B is

represented as being held in the V chucking blocks C C′ on the monitor chucking plate A with the distance piece D supporting the crank pin E and locating it at the correct angle at the same time, the key-seats F F′ having been already cut.

When the key-seat comes in a direct line with the co-axes of the shaft and pin, the position of the pin (and key-seat) is obtained by causing it to abut against a distance piece fixed in an angle plate (or arranged otherwise, as preferred), as shown in Figure 94, which represents an end view of the same shaft, chucking appliances, etc., with the crank

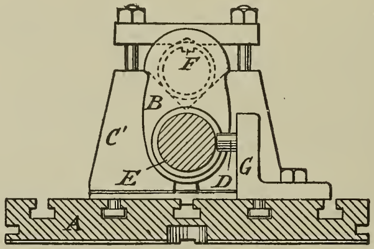


Fig. 94.

pin E (in section as cut through the center) abutting against the distance piece D, which is fixed in the angle plate G.

When the key-seats are milled instead of being planed, the same methods of determining the position of the key-seats may be employed, with whatever modifications are necessary to adapt it to the differences existing in the two machines. Another method which is sometimes employed for the same purpose is a template with one end bifurcated so as to span or clasp the crank pin, the other end being fitted to the crank shaft in such manner that both sides of the key-seat can be laid off (marked) therefrom.

CHAPTER XIII.

Planing, Shaping, Slotting.—*Continued.*

CHUCKING ENGINE BEDS, CYLINDERS, ETC., FOR PLANING.

Vertical engine frames having flat guides, and other surfaces which require planing, and cylinders having plane surfaces (to which the steam chest is bolted), and all similar work is usually planed on an arbor, mounted on V chucking blocks on the platen of the planer after the work has been bored, the arbor being fitted concentric with the bore of the work to ensure the correct alignment of the planed surfaces with the bore. Horizontal engine beds, rectangular

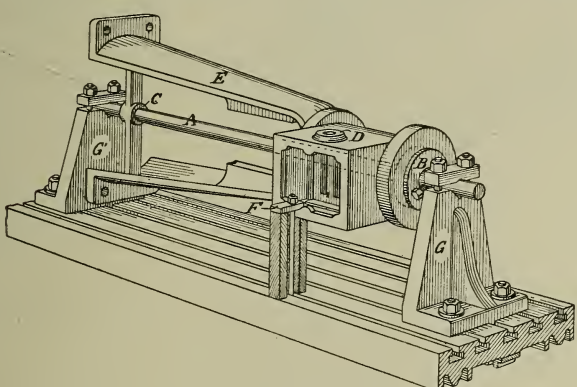


Fig. 95.

steam chests, in which are used valves of the piston type, and similar work is preferably planed before it is bored, the bore being aligned with the planed surfaces.

Figure 95 shows the method of chucking the frame

for a vertical engine (in this case the cylinder, steam chest, guides, and standards are cast in one piece).

The chucking arbor A is aligned with the bore of the cylinder and guides by means of the guide ring B, which is fitted into the counterbore of the cylinder (the guide ring may be turned [stepped] in such manner as to fit the counterbores of several sizes of cylinders), and the guide bar C, which is cast on the frame and bored out for this purpose (and afterwards broken off). The frame E is shown in position for

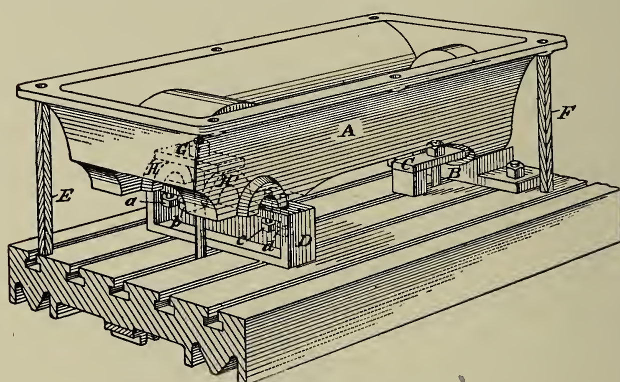


Fig. 96.

planing the boss D, and is held by means of the prop and clamp F.

For planing detached cylinders, etc., the arbor A is aligned with the bore and mounted on the V blocks G G′ in the same way as above.

Figure 96 shows the method of chucking horizontal engine beds for planing the under side or base. The front (semicircular) part of the bed A rests in a shallow V block B, where it is held by the clamp C. The set screws a b c d in the box-shaped chucking block D support the bed on the crank end, and also serve as a means of adjustment in aligning it horizontally and

transversely. When the bed has been set in position for planing, before the clamps are tightened up additional supports in the form of wooden props, as shown at E F, should be placed under each corner or elsewhere, as required. On work of this kind the facilities for clamping it in such positions as shown are always limited; and, therefore, any projections on or depressions in the work must be utilized for this purpose, an instance of which is shown in the engraving where the clamp G is shown (by dotted lines) resting on the inner bosses of the bearings.

CUTTING KEY-WAYS ON THE PLANER.

The principal objection to cutting key-ways on the planer is the difficulty experienced in chucking the

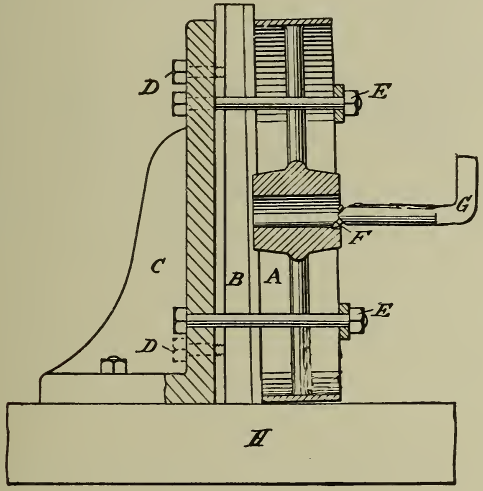


Fig. 97.

work so that the key-ways will be of the right taper when cut. This objection can be entirely removed

by adopting a standard taper for all the work to be key-seated, and then making a pair of taper-chucking bars, preferably of I section, against which the work may be chucked, and by which means it will always be set to the right taper. This is shown very plainly in Figure 97, which represents a sectional view of a pulley A, in position for cutting the key-way, chucked against the taper bars B (or, as they are always termed in the workshop, "taper parallels"), which are held in place on the angle plate C by the bolts D D; E E clamps for holding the pulley, F tool, G tool holder or cutter bar, H platen.

CUTTING KEY-WAYS ON THE SLOTTER.

Key-ways can be cut to much better advantage on the slotting than on the planing machine, because the

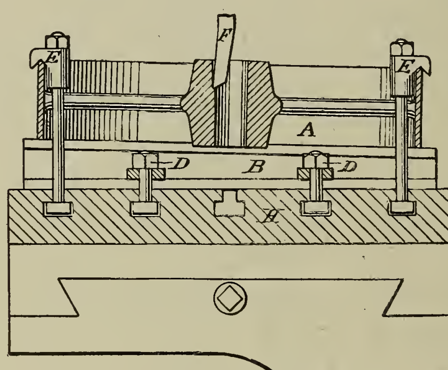


Fig. 98.

work can be chucked much easier and held more firmly on the former than on the latter machine. The method of holding the work on the slotter is much the same as on the planer, as shown in Figure 98, which represents a sectional side view of the pulley

A in position for cutting the key-way, clamped at E E on the taper bars B, which are bolted to the platen (or table) H by the clamps and bolts D D, F slotter tool cutting the key-way.

PLANING WORK BETWEEN THE CENTERS.

There are certain kinds of work which can be operated on (planed) to better advantage if it is chucked or held between the planer centers, an example of which is shown in Figure 99, which

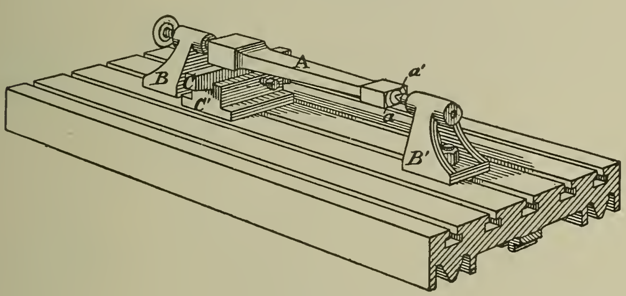


Fig. 99.

represents a connecting-rod chucked between the centers for planing the butt ends. Such work is always centered and then trued and faced off to the right length in the lathe, after which, while the work is still revolving in the lathe centers, the circles a a′ (the diameters of which equal the thickness to which the work has to be planed) are described on the ends of the work by means of a sharp-pointed tool. It is always best to plane the broader surfaces of the work first, and in setting it, the work should be aligned from the under side in preference to the upper side; this can be done by means of parallels of suitable thickness, or by means of the adjustable parallel C C′. The parallel C (the under side of which is an

inclined plane) is fitted into the groove (the bottom of which is similarly inclined to correspond with the under side of the parallel C) in the guide block C′. If the work is very heavy it may be advisable to put parallels under each end to support it. When the broader surfaces have been planed, the quickest and most perfect way to set (square) the work for planing

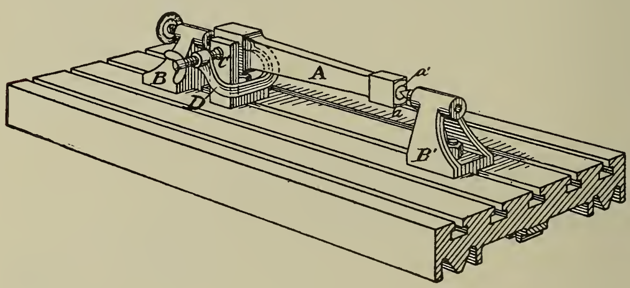


Fig. 100.

the narrower surfaces is by means of the angle plate C and clamp D, as shown in Figure 100. The angle plate should be made about the same height as the centers, and the clamp may be of the ordinary form.

The centers shown in the engraving are of the simple form, but when planing polygonal or other than square or rectangular work, it is best to use the compound or universal form of centers.

CONCAVE AND CONVEX PLANING.

Concaved and convexed surfaces are planed by one of two methods (which are divided into two classes), as follows:

First, by using formers, which changes the position of the tool as the work is fed under it, and second, by using special appliances by means of which

the position of the work is continually changed as it is fed past the point of the tool. In the first case the shape and position of the former is such that, as the work and former are fed past the tool, the tool is raised or lowered in such manner that the work is planed to the same shape as the former. In the second case, the tool is fed transversely or vertically across the surface of the work in the ordinary way, and as the work travels past the point of the tool the chuck, or supplementary table (in or on which the work is held), is made to oscillate upon its pivot in such manner as to cause the work to describe an arc, and to be planed convex or concave, accordingly as the tool is set to cut outside or inside of the pitch line to which the work is set.

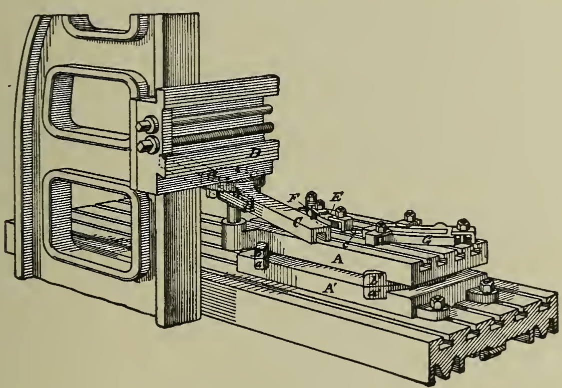


Fig. 101.

Figure 101 represents a planer attachment for planing concave and convex surfaces. The table A A′ is of the compound form; the lower part A′ is bolted to the platen, and has two semicircular slides a a′ upon which the similar slides b b′ (on the under side) of the table A work. The table A is pivoted at c, and

is oscillated by means of the guide block B (shown partly by dotted lines) which works in the slide bar C; the slide bar is bolted to the under side of the cross-rail D, as plainly shown.

The radius of the arc which the table is made to describe on its pivot as it is moved backwards and forwards with the platen is determined by the amount of angularity given the slide bar C, the pitch or center line to which the work is set always cutting the center of the pivot pin c; E G F is the work, shown in the position in which it would be set and bolted on the table A; in this case G represents a link, and E F link blocks for the reversing gear of steam engines (patented).

CHAPTER XIV.

PLANING, SHAPING, SLOTTING.—*Continued.*

GAUGE FOR PLANING V'S AND V WAYS.

Figure 102 represents a gauge which combines the features of both male and female gauges as employed in planing the V's and V ways of machine tools.

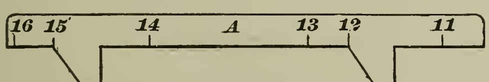


Fig. 102.

Figure 103 shows the gauge applied in planing the V ways on the bottom of a lathe foot stock, A repre-

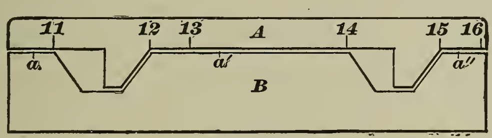


Fig. 103.

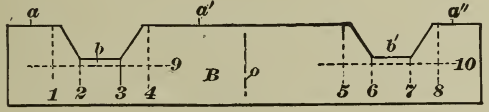


Fig. 104.

senting the gauge, B the work. The upper (plane) surfaces a a′ a″ (Figures 103 and 104) of the work

are first planed to size. The width and depth of the V ways is then laid off from the center line O, simply drawing the perpendicular lines 1 to 8 to indicate the widths of the tops and bottoms of the V ways, and the horizontal lines 9 and 10 to indicate the depth. Or, the ways may be laid off in full by means of the gauge itself, laying one side off first, and then reversing the gauge to lay off the other side. The bottoms of the V ways b b′ should then be planed, after which one side of each V way can be planed at one setting of the swivel head and tool, testing the accuracy of the angles and distance apart by means of the gauge, as shown in Figure 103.

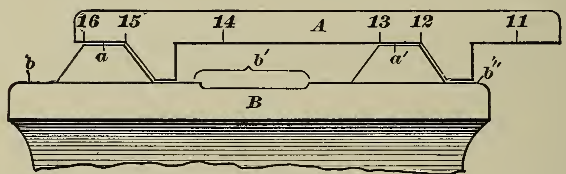


Fig. 105.

Figure 105 shows the same gauge applied as a female gauge in planing V's. The upper and lower horizontal surfaces a a′ and b b′ b″ of the work are first planed to size. The V's are then laid off in practically the same manner as explained above. One side of each V can then be planed and gauged to size without any reference being made to the opposite side of the V's. It is also evident that when the widths of the tops and bottoms of the V's are accurately laid off on the gauge, as indicated by the lines 11 to 16, that the V's and V ways can be accurately planed thereby. This form of gauge is preferable to the ordinary male and female gauges usually employed for this purpose.

GRADUATED PLANER HEAD.

Figure 106 represents a planer head with an ordinary 12-inch steel scale A and a pointer B (fastened thereon by means of the small screws a a′ and b b′), which are intended to facilitate the operation of setting the tool for the cut, as for instance, when it is required to increase the amount the tool is cutting by, say, $\frac{1}{8}$ inch, or to decrease it by, say, 1-16 inch, this can be very closely measured by means of the pointer B and scale A in an obvious manner without any cut and try about it, such as every mechanic must employ when no such means are provided for this purpose.

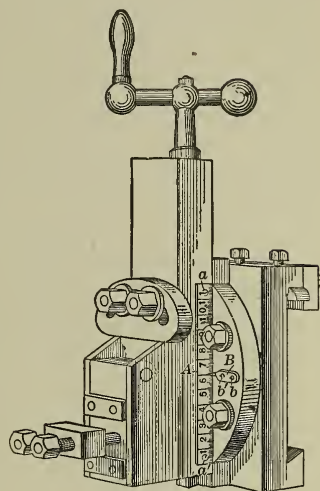


Fig. 106.

STUD BOLTS AND NUTS VERSUS SOLID-HEADED BOLTS FOR PLANER WORK.

In chucking almost any kind of work on the planer, shaper, or other machine having a similar platen, or work table, it will frequently happen that after the work has been set on the platen it is required to clamp the work on the inside, or on the outside in such places as have not been previously arranged for, and that about the time this necessity is discovered, it is also found that the slots in the platen on each

side of the place where the clamps are to be put are already covered by the work, or are stopped off by other clamp bolts, and that an ordinary clamp bolt cannot be inserted in the place desired. In such cases it is usual to insert a T-headed bolt (with the opposite corners rounded off) in the slot. But to carry a full line of such bolts in addition to the ordinary solid-headed clamp bolts, or to have to stop to make one or more T-headed bolts whenever such an emergency occurs (and just when the time for doing so can least be spared), is both inconvenient and expensive.

To avoid such contingencies, and to facilitate the matter generally, we have in our own practice dispensed with the ordinary and T-headed bolts altogether, and adopted a system of stud bolts and nuts in the place thereof. The method, as shown in Figure 107, is to cut away the nuts (which are to be inserted in the slots), as shown in the plan view A and the sectional side elevation B (which also shows the stud bolt), just enough to admit of the nut being inserted in the slot. Before putting the work on the platen (or stopping off the slots as already explained) a sufficiency of these nuts (with the holes plugged with waste) are inserted in the slots in such places as to be always accessible. Then when the work is in place, wherever it is desired to put a clamp, the waste is picked out of the nut and a stud bolt of the right length inserted therein.

Fig. 107.

These stud bolts are practically as strong as solid-headed bolts, and are more convenient than any other form.

SLOTTING MACHINES.

Slotting machines are used very extensively in England and other European countries, but their employment in America does not seem to have met with as much favor as elsewhere, a fact which is to be regretted, because for certain classes of work the slotting machine is far superior to either the planer, shaper or milling machine, and, in the hands of a good operator, the amount and variety of work which can be done on this machine is, to say the least, surprising. It (the slotting machine) is mostly adapted to dressing the internal surfaces of connecting-rod straps, links for reversing gears, etc., and the outer and inner surfaces of irregular shaped work. Usually several pieces of the work can be clamped (bolted) together and dressed (slotted) as though it were only one piece.

CHAPTER XV.

Milling.

MODERN MILLING PRACTICE.

In machine-shop practice, the term "milling" signifies the shaping of metals by means of rotary cutters on machines specially designed for the purpose, or on other machines that have been changed and fitted up for this purpose.

It is only of late years that milling has attained the important position it now occupies in modern practice. But so rapidly has this system of cutting or dressing the surfaces of metal work been developed, that it has almost entirely superseded all other methods formerly employed for the same purpose. And since the introduction of "gang mills" and "formed cutters," the capacity of the milling machine has been gradually extended and its scope broadened until it is now employed for shaping and finishing an almost endless variety of work.

When the machine is properly selected, with an intelligent view to its adaptability, such as the work that has to be done upon it may call for, it will be found that this is a remarkably efficient and economical machine, and that, for the quantity and quality of work which can be done on it in a given time, it is superior to any other machine tool in existence; that is, when the machine is operated or supervised by an expert operator.

When the cutters and chucking appliances are

properly designed, and the cutters and work are once set by a skilled supervisor, one operator (and frequently an unskilled hand at that) can usually attend to two or more machines at the same time, as in such cases, when the cutters and the first piece of the work have been once correctly set for the operation, the duty of the operator consists in merely starting and stopping the machine, and changing the work in the chuck, as required. In other cases the nature of the work may be such that none but a skilled operator can handle it successfully, and that he will have to give his whole undivided attention to the machine and work as long as the operation continues.

Sometimes the conditions can be modified and the process simplified by making the machine semi or wholly automatic, or by making such other changes as will expediate or facilitate the process.

Many of the most important improvements in milling-machine practice have been made by individual superintendents, and operators in their own practice, in adapting and making the cutters and other appliances to suit their own requirements and work. In such cases these improvements are, as a matter of course, naturally regarded as personal property, and are therefore seldom made known outside of the shop in which they are introduced and used.

After all there is nothing very wonderful in the performance of the milling machine, for in milling, each tooth of the cutter is equivalent to a separate single-point tool, and is only in actual cutting contact with the work during a period which seldom exceeds one-tenth of the revolution of the cutter, thereby making it possible to increase the cutting speed for all kinds of work (without overheating the cutters) up to from three to five times that of a single-point cutting tool. And furthermore, as there is always two or more teeth of the cutter in cutting con-

tact with the work at the same time, the feed can be increased in proportion to the number of teeth among which the cut is divided.

To get the best and most satisfactory results in milling cast iron, wrought iron, brass and other metals, the cutters should be specially made and adapted as regards the shape, pitch, and angles of the teeth, for the material to be worked, as in similar processes on other machines. The speed of the cutters should be as great as can be employed without dulling the edges of the cutters, and the feed should be as heavy as the machine can drive, and the work and cutters admit of.

What would constitute the ordinary practice of one operator or concern, having a thorough knowledge of milling processes, and possessing every facility in the way of appliances and cutters for doing the work, would be considered very advanced practice by other operators or concerns not so well acquainted with milling processes, and not possessing any but the ordinary facilities for doing the work.

In the latter cases, the work turned out on the machines is usually of such an indifferent and unsatisfactory nature, as regards the quantity and quality, that it is not at all an uncommon sight in such shops to see the milling machine standing idle, while the planing, shaping, and slotting machines are fully occupied on work which could be done to better advantage and in a fraction of the time on the milling machine, if the capacity of the latter machine was better understood.

It is not deemed necessary to describe in detail the ordinary milling processes, as the subject has been very thoroughly discussed and treated of in journals and books.

Such examples of modern milling practice as are shown (by permission) in the following pages are

taken from the present practice of individual concerns, and represent the application of certain milling devices designed and employed for special purposes, and which it is thought might furnish a basis for improvement, or be of service in other processes.

DOUBLE GANG MILLING.

Figure 108 shows a double gang milling arrangement, designed and employed by Mr. Garland, for milling the shears and upper surfaces of lathe beds and other work at one operation.

As shown therein, the two sets of gang mills are both in operation at the same time, one set A′ taking the roughing, and the other set A the finishing cut. They are driven from an overhead drum by means of the pulleys and reducing gearing B B′. The work W is fed under the mills by still further reducing the planer gearing (motion), as shown at C C′; the pulleys C being driven from the same drum as the gang mills. The original quick return motion of the planer is fully retained by arranging the belt shippers in such manner that, when the work is being fed under the cutters, the original belt is running on the loose pulley, or else stopped altogether, and when the motion of the platen is reversed, the feed belt is shipped onto the loose pulley and the original belt onto the tight pulley.

The mills can be run one set under and the other set over, or, as it is sometimes termed, "on and off" the work, as arranged.

Objection may be raised to roughing and finishing the work at one operation, on the supposition that the work should always be loosened and rechucked for the reasons explained in Chapter X, but an extended experience with this method of milling has shown very

conclusively that it is very rarely necessary to re-chuck the work if it has been properly chucked in the first instance. In fact the work turned out by this

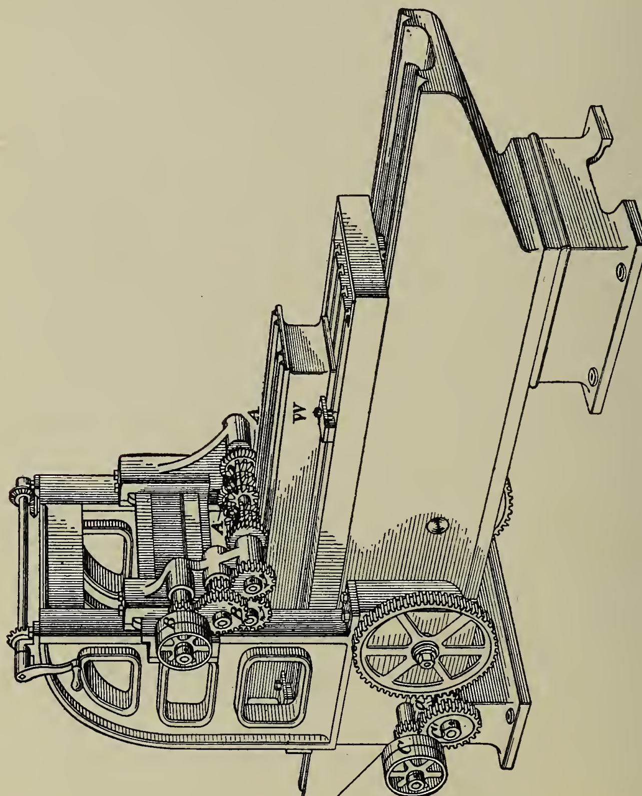


Fig. 108.

method is found to be as fully up to the standard as when milled by any other method.

Another advantage of this method is the entire absence of any jar or vibration, owing to the manner in which the mills are run.

FACET AND SURFACE MILLING DEVICE.

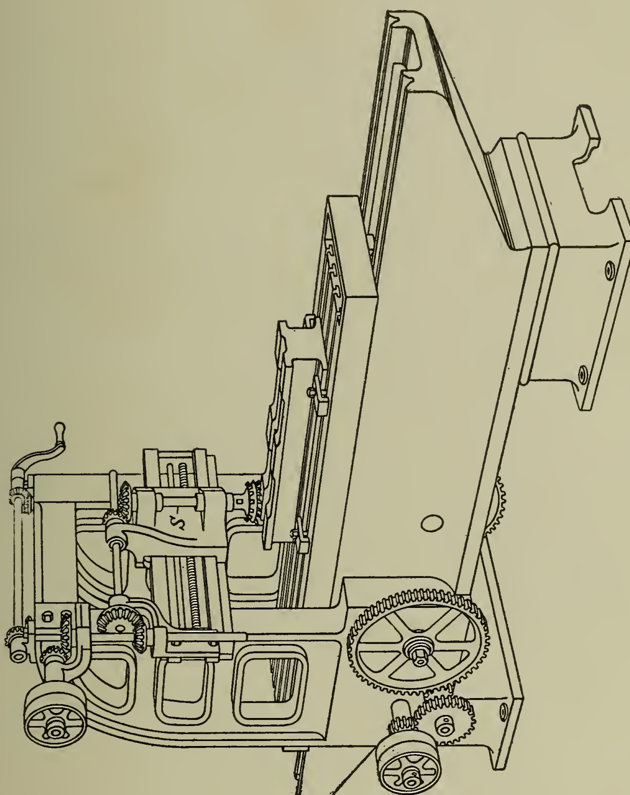


Fig. 109.

Figure 109 represents a vertical spindle milling device employed for "facet" and general surface milling. As shown in the figure, the device has been specially designed for the purpose, with a view to its adaptability and application to an ordinary planing machine.

The work is fed under the cutters by still further reducing the planer gearing, and the machine and cutters are operated from an overhead drum, as in the preceding example.

Unlike most other devices that have been applied on the planer for the same purpose, this device admits of a ready adjustment both transversely and vertically; transversely, by sliding the cutter-head across the cross-rail in the same manner as the planer head, and vertically, by raising or lowering the cross-rail in the usual way.

The upper part of the vertical spindle S is inclined forward (from a true vertical plane) about $\frac{1}{3000}$ of an inch to the foot to prevent the cutters from dragging on the work after their circuit of cutting contact has been completed. This, of course, leaves the surface of the work hollow (concaved) in proportion to whatever amount the spindle is inclined forward, but if the inclination of the spindle is restricted to the amount specified it is scarcely perceptible on the surface of the work, and yet it is sufficient to allow the cutters to clear the work on the back of the cut.

In some cases the feed motion is operated by means of a worm and worm gear, and the mills are also occasionally operated by the same means.

CHAPTER XVI.

Milling.—*Continued.*

FACE MILLING.

A very popular method of milling is "end" or "face" milling. One reason why this is so, is that, when milling plane vertical surfaces, any face mill, whose diameter exceeds the depth of the surface to be milled, can be employed for that purpose without having to take into consideration the thickness or diameter of the cutters as in other processes.

This form of milling would be still more popular if the facilities for chucking and operating on the work were in all cases equal to the requirements, but, unfortunately for the operator (and for this particular method of milling), such facilities are not always available, and so the work has to be chucked direct to the machine platen, which necessitates the resetting and rechucking of the work for every surface to be milled. Therefore other methods of milling the work are frequently employed in preference to this, as the work can be more readily reset and chucked as the various surfaces are operated on.

There is probably no other form of chuck so eminently adapted to the purpose of holding the work while it is being operated on by this process as some one of the many forms of "monitor" chucks. The simplest forms of these are shown in Figures 90, 91 and 92. As shown therein, the chuck is made of a size suitable for planer work. For milling-machine

work the construction of the chuck would be precisely the same, but the size would be reduced to suit the machine and work.

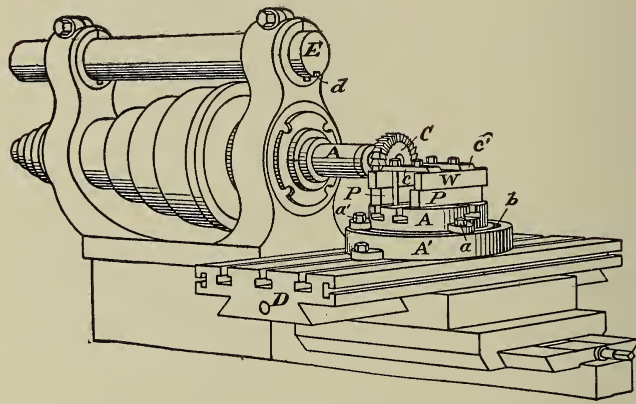


Fig. 110.

A special form of monitor chuck designed for this purpose is shown in Figure 110, with the work chucked in position thereon as it is being operated on. As shown therein, the chuck consists of two parts, a revolving plate A and a base plate A′. The base A′ is located by means of a tongue on the under side in the center T slot of the platen D. The revolving plate A (upon which the work W is held on the parallels P P by the bolts and straps c c′) is pivoted in the center, and is held in position by the bolts a a′, which are inserted in a circular T slot in the base A′. When one surface has been operated on, the chuck and work are revolved until the next surface is brought into position for the operation.

It would be impossible to enumerate herein all the many and varied kinds of work that is and can be held on this chuck while it is being operated on.

DOUBLE FACE MILLING.

Another method of milling the vertical surfaces of work is by means of "twin" or "straddle" mills, whereby two or more surfaces of the work are milled at the same operation.

This form of milling is very popular, and is preferred to any other method whenever and wherever it can be successfully employed.

So far, however, in general practice, double "face" or "end" milling has only been accomplished by two methods: First, by means of "twin" or "straddle" mills, and secondly, by means of double-headed milling machines specially designed and constructed for the purpose, the latter machine usually giving the most economical and satisfactory results.

Whenever straddle mills are used their diameter can never be less than twice the width of the surface to be milled, plus one-half the diameter of the arbor on which they are chucked, and if the nature of the work is such that the clamps and bolts, by which it is held, project above the same, the diameter of the mills must be still further increased by just twice the amount the clamps and bolts project above the work. Which considerations all tend to retard the more extensive employment of this method, as they necessitate the employment of cutters of such excessive diameters, that the cost of making and maintaining, and the power required to run such cutters are considered the most serious and almost the only objections to their employment.

With double-headed milling machines the objections mentioned above are entirely obviated, as double face milling can be accomplished with the same facility as single face milling, the condition being precisely the same in both cases.

In private practice double face milling has been accomplished in a most gratifying and satisfactory manner both on internal and external vertical surface milling on the ordinary plain milling machine, without resorting to either of the above-mentioned methods, some examples of which are shown in the following illustration and pages.

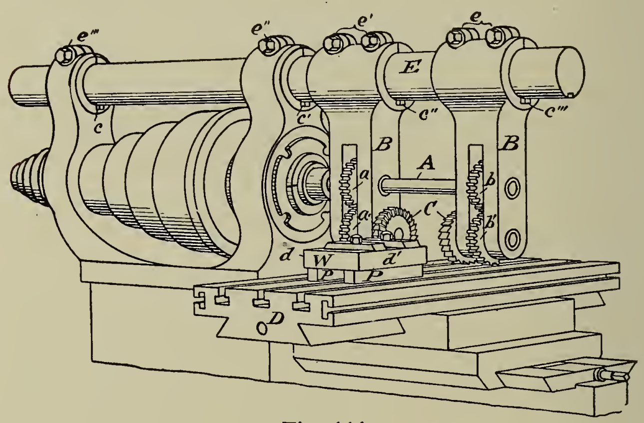


Fig. 111.

Figure 111 represents a method of double face milling on an ordinary single-headed milling machine.

The cutters C are each held on a separate arbor (or spindle), and are journaled in the supplementary brackets B B, which are adjustable on the overhanging arm E, to which they are, when once set, held by the keys c″ c‴ and the binding screws e e′, the overhanging arm E being held in its own bearings by the keys c c′ and binding screws e″ e‴. The work W is shown in position clamped on the parallels P P to the platen D ready for milling the surfaces d d′, the cutters C being driven by means of the gears a a′ and b b′ from the main spindle (arbor) A.

By this method the diameter of the cutters (face mills) can always be less than one-half of that required for straddle mills, and here, as in the ordinary practice of single face milling, any cutters, the diameter of which exceeds the depth of the surfaces to be milled, can be used for this purpose. There is a good deal less springing of the cutters from the work with this method than there is when straddle mills are employed.

It is necessary in this case, as in other milling processes, to employ an efficient outboard support to brace the overhanging arm E and spindle A.

INTERNAL DOUBLE FACE MILLING.

The milling of internal vertical surfaces is not practised to the same extent that outside face milling is, as rotary cutters are not as well adapted to this class of work and the results are seldom as satisfactory as when other methods are employed, unless the nature of the work is such as will admit of the cutters passing right through or across the surfaces to be milled, in which case it is possible to use "twin" or double "face" mills of large diameter, or in other cases to mill the surfaces by means of slab mills of small diameter operated on a vertical spindle, the latter form being generally used for milling the inner surfaces which terminate against the shoulder or against other surfaces of the work.

By either method of milling, when the abutting corners of the work terminate at a sharp point, the surfaces can only be milled up to a point where the cutting edges of the mills come in contact with the opposing surface of the work, leaving the corners of the work to be finished by other processes; a better understanding of which can be had by referring to these methods as shown in Figures 112 to 115 inclusive.

Let it be supposed that the outer surfaces d d′ of the connecting-rod strap or work W (Figure 112) (which is also the same as shown in the two preceding examples, Figures 110 and 111) have already been milled,

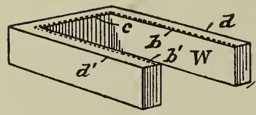


Fig. 112.

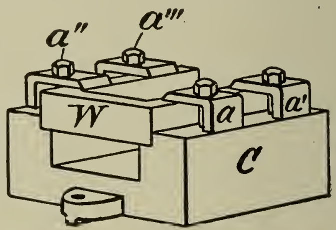


Fig. 113.

and that it is required to mill the inner surfaces b b′. The clamps should be changed from the inside to the outside of the work, or, the work should, when made in large quantities, be held in a special chuck, such as shown in Figure 113, where W represents the work (as before), C chuck, a a′ a″ a‴ clamps and bolts by which the work is held.

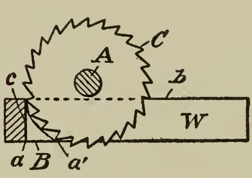


Fig. 114.

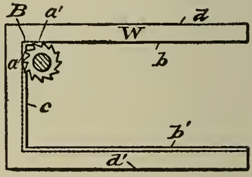


Fig. 115.

Figure 114 represents a side view of Figure 112 (partly in section), and is intended to show how the inner surfaces b b′ are milled by means of twin face mills, A representing the arbor on which the cutters are held, C cutter, W work.

It will be noticed that the cutter C has milled the surface b as far as c, and that a space B from a to a′ is left unfinished, and that this space will have to be finished by other means.

In some respects slab milling is preferable to twin or double face milling on work of this description, for although it is only possible to mill one surface at

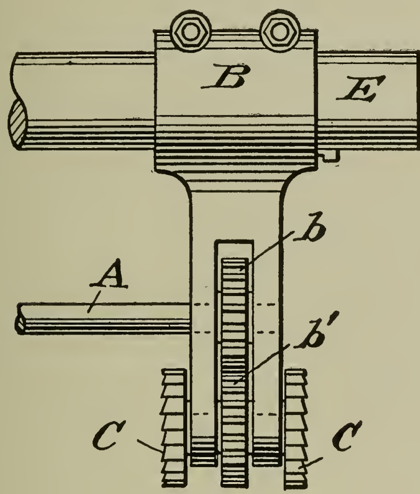


Fig. 116.

a time, still all the three surfaces, b, c and b′, can be milled at one operation, and one setting of the cutter and work, by simply changing the direction of and reversing the feeds as required.

There still exists, however, the same objection of having to finish the corners of the work by other means, as will be seen by referring to Figure 115, the space B from a to a′ being left unfinished, as in the preceding example.

By the employment of a method similar to that shown in Figure 111, internal face milling can be accomplished with almost the same facility as outside face milling.

It is accomplished by means of a pair of twin face mills arranged as shown in Figure 116. The cutters C C are fixed on an independent chucking arbor which is journaled in a supplementary bracket B, attached to the overhanging arm E, and driven from the main spindle A, of the machine, by means of the gears b b′.

By this means cutters of smaller diameter can be employed and the corners of the work can be finished as perfectly as by any method known, by simply changing the direction of the feed (when the cutters have milled as far as the corners of the work) from the longitudinal to the vertical.

This form of mills can only be employed in those cases where the distance between the surfaces to be milled is sufficient to admit of the cutters being arranged and driven in this manner.

Where the inner surfaces of the work are too close together to admit of the cutters being arranged and driven, as shown in Figure 116, the device has been still further modified, and are arranged, as shown in Figures 117 and 118, Figure 117 representing a front, and Figure 118 an end elevation of the device. Motion is imparted direct to the cutters by means of the rawhide gears b b′ which are driven by the main spindle (as before), the cutter teeth being made to serve as gears for their own rotation.

The teeth of the cutters are backed off somewhat more than in ordinary practice, and the clearance space between the teeth is made extra ample to allow room for the lodgment of any small chips that may accidentally adhere to the cutters when operating. In backing off the teeth they are made of such shape on

the back that they will mesh correctly with the gear teeth. A rawhide gear is preferable to a metal gear for this purpose, and if the disengaged side of the gear teeth strike against the cutting edges of the mills, this side of the gear teeth should be relieved sufficiently to clear the same.

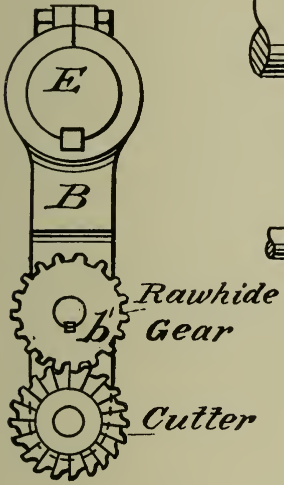


Fig. 118.

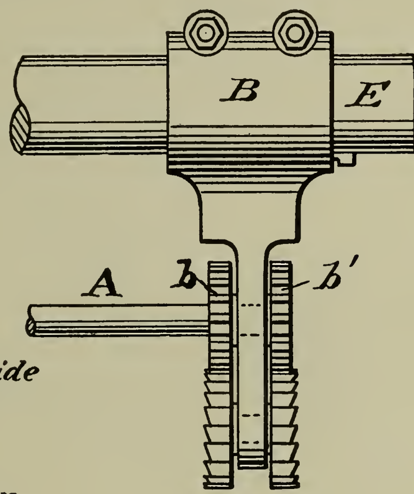


Fig. 117.

Another adaptation of the above device is shown in Figure 119. It is employed for milling the inner surfaces of work in which the frame or other parts project to such an extent as to render it necessary to employ cutters which can be operated in advance of the main spindle A and overhanging arm E of the machine, or, in other machines, in advance of the cross-rail.

The latter forms of milling devices (in which the motion is imparted direct to the cutters) are never

employed except on small work, and it frequently happens that there is not much of the work for which the devices are constructed to be milled. But as there is in most cases other work upon which they can be used (and for milling which other special tools would have to be made), their sphere of usefulness and capacity can be greatly extended if they

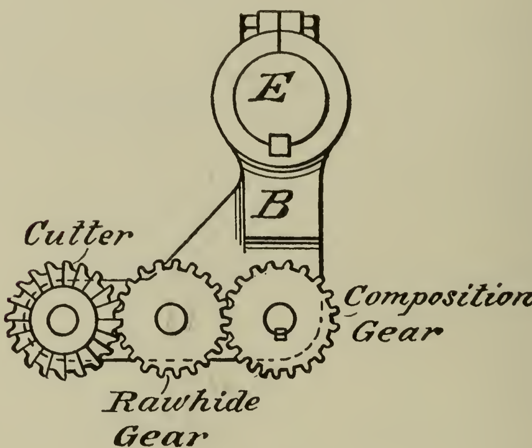


Fig. 119.

are employed on such work, thereby saving the cost of making and maintaining other tools for the purpose.

Figure 120 represents the application of the above device (Figure 119) in milling the inner surfaces of the double eye of a reach-rod. The application of this device to this purpose is of more than ordinary interest, as it admits of the employment of a feature in the design of the double eye which is seldom used on account of the difficulty experienced in finishing the inner surfaces.

As shown at A, Figure 121 (and by dotted lines in Figure 120), the construction of the double eye differs from the ordinary open-ended form (shown at B) in having a thin web of metal extending from one eye to the other, and about one-third of the way around the outer circumference, thereby strengthen-

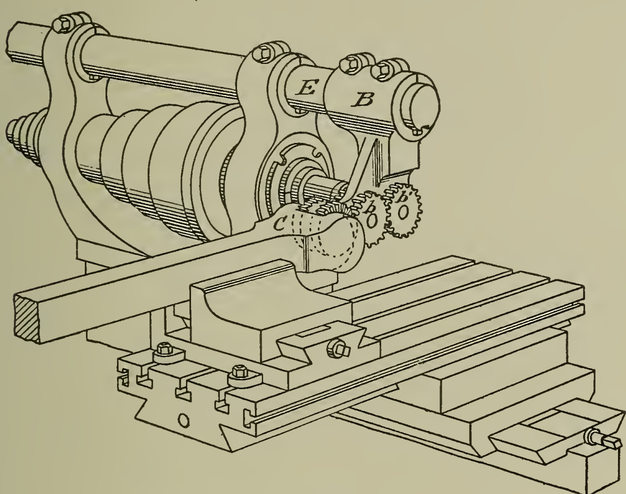


Fig. 120.

ing both eyes and making it possible to employ a lighter form of construction.

When the mills are driven, as shown in Figures 117 to 120, provision must be made for preventing the chips from sticking between the teeth of the cutters.

On cast-iron work this will seldom occur, but on wrought-iron and steel work, where the cutters are always lubricated or cooled by means of oil or other liquids, such as "soap" or "soda" water, the teeth are likely to get clogged up with chips, the result of

which is disastrous to both gears and cutters. The best way to prevent this is to brush the chips away, which is done by mechanical means in a very efficient manner, by employing either rotary or reciprocating brushes, actuated by suitable mechanism from the main spindle of the machine.

The foregoing examples of milling have been carefully selected from many others, to show what can be

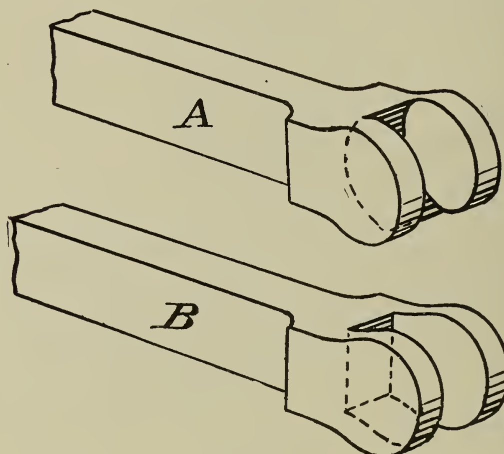


Fig. 121.

accomplished by the employment of special milling devices when applied (on the ordinary milling and other machines) intelligently to the milling of surfaces that are inaccessible or difficult by the ordinary methods, or by means of which the ordinary methods can be still further simplified and made more efficient.

Milling, according to the prevailing practice, has been almost reduced to a science. The expert operator now arranges his cutters and chucking

appliances, and regulates his speeds, and feeds with such precision and accuracy, that when the cutters and the first piece of the work have been once set for the operation, an almost unlimited number of the pieces can be milled with the same accuracy as the first piece. This is mainly owing to the manner in which the milling cutters are backed off or relieved for the clearance angles, for no matter what the shape of the surfaces to be milled may be, the cutters for milling these surfaces are relieved in such manner that no amount of grinding will effect their shape or accuracy, except to reduce their diameter somewhat, which is in most cases easily remedied by resetting the work to a like extent.

In addition to the capacity of the milling machine for doing most of the work upon which the planing, shaping, and other machines were formerly almost exclusively employed, its capacity has of late been still further extended to cover many important operations usually performed on the lathe, such as milling the rims and faces of gear blanks, sheave, and flange pulleys, and a variety of similar work, the operations being performed equally as well and in a fraction of the time on the milling machine that it takes to perform the same operation on the lathe, as all the external surfaces can be milled at one operation on the milling machine, whereas it always requires one or more operations for each surface on the lathe.

The improvements and progress made in the construction of milling machines of late years indicate that the milling machines of the future will not be built on the same lines as the milling machines of the past, but that the machines of the future will be designed and built more specially with a view to handling the work to be done thereon.

The special milling appliances shown in the forego-

ing illustrations are represented as applied on the milling machines built by the Pedrick & Ayer Co., of Philadelphia, Pa., but are equally well adapted to other types of machines possessing the same desirable features, i. e., first, of having a good, rigid outboard support, and secondly, of the ease with which such appliances can be fitted and applied to or removed from the overhanging arm.

CHAPTER XVII.

Lathe Work.

THE ORDINARY AND SPECIAL FORMS OF THE LATHE.

The lathe is still considered (as it always has been and probably ever will be) the most important of all metal-cutting machine tools, which is due in a great measure to the fact that no other machine tool employing a single point tool has so far been designed or built that is capable of such a wide range and variety of purposes and operations as the lathe is. Nor has the introduction of the "turret" lathe, the many forms of the "boring mill," "screw machines," "shafting lathes" and a variety of other special forms of the lathe served to lessen the importance of the lathe in any sense whatever, for the use and employment of all these special forms of the lathe is always restricted to the particular kind of work and operations for which the machines were designed and built. Therefore, though the employment of such special machines must of necessity be taken as representative examples of the most advanced practice of this the present day, when successfully applied for doing the work for which they were intended, it is doubtful if the employment of such machines and methods can be strictly regarded as representing, in the general application of the term, "the most approved practice of the day," any more than the commoner methods of doing work on the lathe, which are a thousandfold more extensively employed in every-day practice, and which, when the amount, requirements and other conditions are taken into account, are, comparatively speaking, run on an

equally profitable basis. And when the ordinary facilities for doing work on the lathe are further improved upon to suit the requirements of the work, which they can be in nearly every instance, the operations can be performed on the lathe with an expedition and accuracy that will compare very favorably with the machines specially designed for the purpose. For instance, if the work is turning shafts or shafting, additional tools held in a substantial follower-rest mounted in the cross-slide of the lathe carriage are employed to expediate the operation. If the work is turning or (and) boring pulleys, discs, gears, etc., the chucking appliances and tools should be such as this class of work may call for. Or, when the work is studs, bolts, pins or such work as could be done on a turret lathe, the chucking appliances are made and adapted to the work, the tool rest is removed altogether and a turret rest substituted therefor, which latter appliance practically converts the ordinary lathe into a turret lathe, and which was successfully accomplished over twenty years ago.

Such changes as those referred to above are not as a rule of an expensive nature, and the great advantages to be gained by the employment of such when properly handled are always of a satisfactory nature. And when we take into account the actual cost and maintenance of special machines, which, though perfectly adapted for and capable of doing the work for which they were designed, would in all probability be standing idle a greater part of the time (except in those shops that have plenty or make a specialty of the work, for doing which such machines are employed), and calculate the probable gain likely to result from the use thereof, as compared with the cost of the same operations when performed on the lathe, and especially if the latter is fitted up and arranged in a manner suitable for handling the work to the best advantage,

we shall find that the result will in most cases be in favor of the lathe.

An expert lathesman is usually supposed to be capable of skillfully handling and operating any and all other kinds of machine tools, as the principles governing the operation of all other metal-cutting machines and the tools employed thereon are (with the exception of the milling machine) similar to those of the lathe.

In ordinary practice the average machinist rarely if ever makes use of any calculations in or for determining the speed at which his work or cutting tools should be run. He usually applies the knowledge he has acquired on this subject by actual experience and observation to this purpose, and, although it may appear to an ordinary observer, when the work or tools are speeded in this manner, that it is only guess-work, it will be found on trial that such really is not the case, but, on the contrary, the speed exceeds in nearly every instance the rate that is generally supposed to be the most economical limit at which such tools or work should be run.

On cast iron the cutting speed has been fixed (from comparisons, and data collected) at from thirteen to sixteen circumferential or longitudinal feet per minute. And for other metals as follows:

Wrought iron, fifteen to twenty feet per minute.

Steel, eleven to sixteen feet per minute.

Brass, twenty-five to forty feet per minute.

These excessive variations are dependent on the following circumstances and conditions:

First. The number of surface feet to be dressed at one setting of the tool.

Second. The density and toughness of the metals.

Third. The shape and form of the tool or tools employed, and

Fourth. Whether the cut taken over the work is a

roughing or a finishing cut, and if the tool is cutting on or below the scale or skin of the work.

Quite frequently the nature of the work renders it necessary to employ a tool with the cutting edges standing at such a distance from the tool part or rest that ordinary speeds and feeds cannot be employed thereon. In other cases the texture of the metal may necessitate the employment of slower speeds and finer feeds. Then again, for the same reason, it may be possible to use quicker speeds and coarser feeds.

It is therefore impossible to give any definite rule by which either the cutting speeds or rate of feed can be accurately calculated or even estimated.

On roughing cuts, the rate of feed varies from $\frac{1}{50}$ to $\frac{3}{16}$ of an inch, and on finishing cuts, from $\frac{1}{32}$ to $1\frac{1}{2}$ inches per revolution of the work or cutter, or per stroke of the machine or tool.

It is not our intention to discuss or attempt to give instructions or formulate rules on a subject where so much depends upon the practical knowledge and intelligence of the operator or supervisor, but it may not be amiss to state that individual experience and energy alone can crown with success the efforts of the operator to excel in this important branch of mechanics.

It is presupposed that the reader is already acquainted with (or can from other sources acquire a knowledge of) the uses and manner of operating any or all of the special forms of the lathe; and it is thought that it will be more important and advantageous if we confine the following chapters on lathe work to the illustration and description of a variety of the methods of doing work on the ordinary lathe by means of such special appliances and improvements as have been designed and employed for doing work which is now in many instances done less perfectly and at greater expense by other methods.

Although so much can be accomplished on the lathe with only the ordinary facilities for doing the work, there is no question whatever as to the advisability or necessity of improving on the ordinary methods by employing any appliance in the way of chucks or tools that will expediate or facilitate the process. But, whatever form the chucking appliances may partake of, the same principles and rules must be observed in their construction that govern the construction of the chucking appliances of other machines, for the work can be sprung just as easily on the lathe, in clamping, as on any other machine, and for this reason the chucking appliances should be such as will not create any strains in or on the work.

CHAPTER XVIII.

Lathe Work.—*Continued.*

BORING TOOLS.

The cutting edges of the tools employed for boring work in the lathe require to be shaped with greater accuracy and precision than is necessary for turning tools, for the reason that they are always used for shaping and trueing the inner surfaces of work, and the space in which they are to operate is usually of a contracted nature, thereby necessitating a more slender construction of the body of the tool in proportion to the work they have to do, a disadvantage which is still further intensified by the fact that the cutting edges of the tool must in most cases stand further away from the tool post or rest than the tools for outside turning.

So ably have the requirements and merits of the different shapes and forms of lathe tools been set forth and discussed in the latest works on this subject, that it is not thought necessary to attempt a dissertation (which would only be a repetition of what has already been said) on this particular question. We shall therefore confine ourselves in this chapter to the consideration of a few special forms of boring tools.

IMPROVED CUTTER BAR FOR BORING.

Figures 122 and 123 represent a plan and perspective view of a boring tool bar with inserted cutter, designed by Mr. C. E. Loetzer, Auburn, N. Y. (not

patented). It will be seen that the point of the tool is in advance of the end a of the bar, and that the position of the head b of the binding screw is such that it does not project beyond the end a or the side c

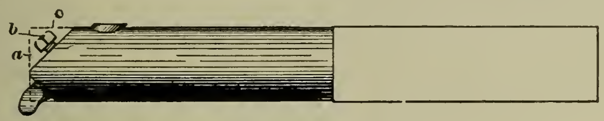


Fig. 122.

of the bar, thereby avoiding the three most objectionable features of the ordinary tool holders or cutter bars of this description, viz.: First, of having to bend or offset the shank of the tool to permit the point to

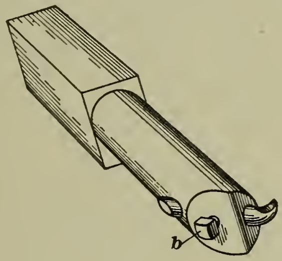


Fig. 123.

stand in advance of the fore-end a of the bar. Second, of having to reduce the diameter of the bar when the binding screw is inserted in the upper or under side of the bar, and Third, of having to chuck the work so far away from the jaws of the chuck or face-plate of the lathe, to allow of the tool passing through the bore of the work.

It is therefore possible with this tool holder to bore a smaller hole, and to bore closer to the chuck or face-plate without having any undue springing of the tool.

This method of arranging the tool and binding screw in the fore-end of the cutter bar can be used on other forms of tool holders, on lathe and planer work.

BORING AND DRILLING ATTACHMENT FOR LATHES.

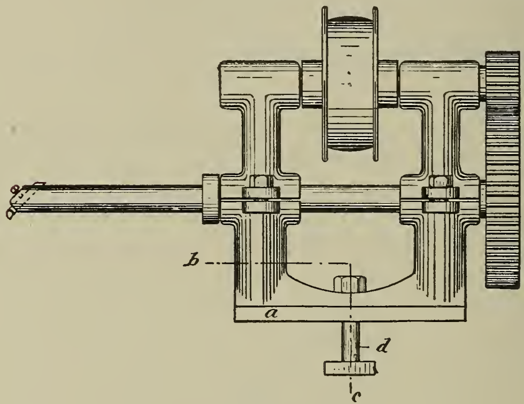


Fig. 124.

Figure 124 represents an attachment for boring crank pin-holes when the crank is held between the centers of the lathe or is chucked on the face-plate for boring and facing for the shaft. The attachment is held in the rest in place of the tool post, and has a

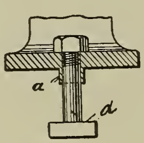


Fig. 125.

tongue a on the under side (shown to better advantage in Figure 125, which represents a sectional end view of the base cut through the lines b c, Figure 124), which

fits into the T slot of the tool rest, the bolt d holding it in position. The attachment is driven from an overhead drum, or an extra pulley on the counter-shaft.

When arranged for holding drills, it can be employed for drilling and boring holes in work of any kind that is chucked to the face-plate or held between the centers of the lathe, and is particularly adapted to drilling and boring the pivot pin holes in governor wheels or discs, and for all similar work, the tool being fed through the work by means of the regular carriage feed.

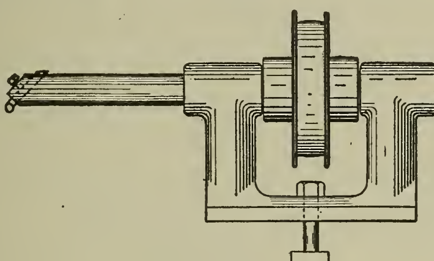


Fig. 126.

For small work, or when preferred, the attachment is made (without the reducing gears), as shown in Figure 126, with the driving pulley fixed directly on the boring bar.

CUTTER HEADS.

In boring operations, when the diameter of the hole to be bored will admit of it, a cutter head is fixed on the boring bar for holding the tools, instead of holding them in the boring bar itself. The cutters (tools) are held in the head in a variety of ways, all of which are more or less open to objection, either from having to offset the body of the tool to boring the cutting edges even with or in advance of the front part of the

cutter-head, or from the difficulty experienced in removing or adjusting the cutter. Figures 127, 128

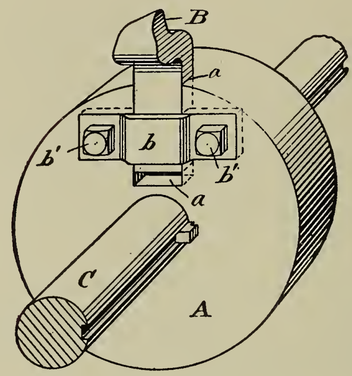


Fig. 127.

and 129 show three of the ordinary methods by which the cutters are held in the cutter-head.

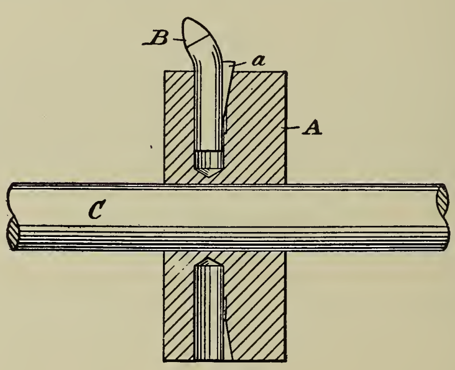


Fig. 128.

In Figure 127 the tool B is inserted in the slot a a (in the cutter-head A, which is keyed on the boring bar C), and held by the clamp b and cap screws b′ b′.

This is an excellent way to hold the tool, but on many kinds of work the tool has to be offset, as shown in the figure.

There is probably no other method of holding the tool in the cutter-head employed as much as that shown in Figure 128, where the tool B is held by means of the key or wedge a. The chief objection to this method of holding the tool is the difficulty experienced in removing the tool from the head, and in making the necessary adjustments for the different cuts.

A better form of cutter-head than either of the above is shown in Figure 129; by this method straight cutters are used, and are held in place by the binding screws b, which are inserted in the counterbored recesses a a. The cutter-head A is held on the boring bar C by the set screw c.

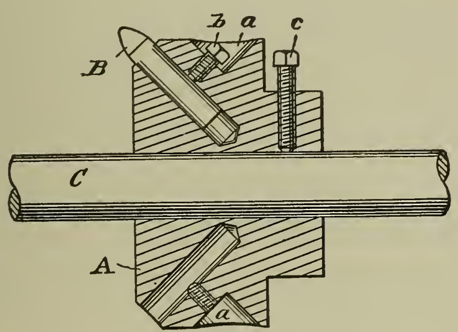


Fig. 129.

In this cutter-head the objections of the preceding forms are entirely removed; and the only objection to this form is that it is heavier than necessary, and no adjustment of the cutters can be made when the cutter-head is on the inside of the work, as in boring the

counterbore on the inner end of an engine cylinder, when the back cylinder head is in its place, or forms a part of the cylinder casting.

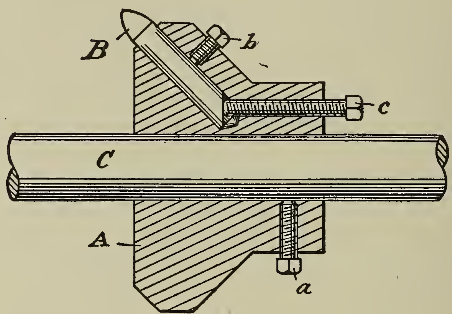


Fig. 130.

Figure 130 shows a form of cutter-head that is superior to any of the above, inasmuch as it has none of the objectionable features of the other forms of cutter-heads. It is held on the boring bar C by means of the set screw a; the tool B is held by the binding screw b, and can be set out (adjusted to the cut) by means of the adjusting screw c, which adjustment can be made in such cases as that mentioned above, when the cutter-head is on the inside of the hole that is being bored, if such adjustment is required. A feature not possessed by any other cutter-head of which we have any knowledge.

BORING BARS FOR BORING SPHERICAL HOLES.

Some builders of engines and other machinery employ on certain parts of their machines a form of bearing or joint termed "swivel bearings or joints," the object of which is to prevent any undue cramping of the shafts or wrist pins in the bearings or boxes, aris-

ing from a possible disturbance in the alignment of the parts from any cause whatever.

On engines this form of bearing and joint is confined to the crank-shaft bearings, the crank pin and connecting-rod brasses (usually on the crank end only) and the wrist pin on the valve rod slide. On other machines they are used for various purposes.

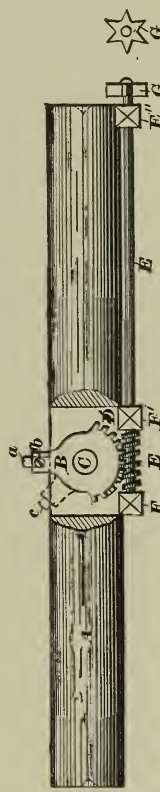


Fig. 131.

In all these forms of bearings and joints, the boxes, straps, or pillow blocks are always bored semicircular or biconcave, and the bearings (liners, formed in sections), journals and wrist pins convex or spheroidal.

For boring out the pillow blocks and boxes of large sized bearings the boring bar shown in Figure 131 is employed.

A represents the boring bar, broken away in the center to show the cutter-head B, which is pivoted on the pin C, and geared at D to engage with the worm and feed-shaft E E, F F′ F″ bearings for the feed-shaft, G G feed star. The tool a is held in the cutter-head B by the binding screw b.

Another form for smaller work is shown (partly in section) in Figure 132. In this form the construction is more intricate, but the principle is precisely the same.

In the figure A A represents the boring bar, B cutter-head, pivoted at C, and connected with the slide E and feed-screw F by means of the connecting-rod D, G inner bearing for feed-screw F serving also

to hold the slide E in position, G′ outer bearing for feed-screw, I I line of intersection, cutting the bar A, as indicated in the sectional side and end elevations (Figures 132 and 133), to show the way in which the bar is grooved on the end for the feed-screw F, J J (Figures 132 and 134) similar line of intersection and elevations, to show the manner in which the bar is recessed for the slide E and rod D.

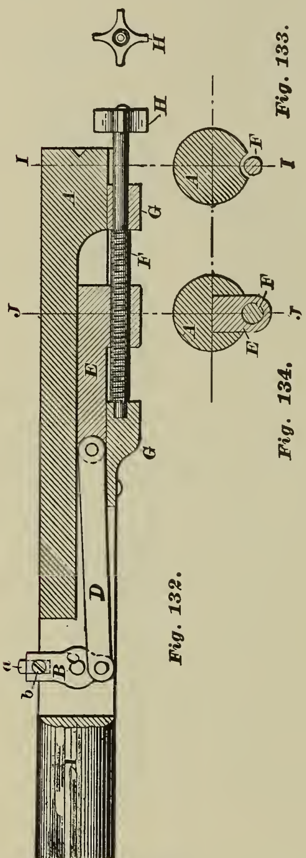


Fig. 132.

Fig. 133.

Fig. 134.

In using these bars the work is first aligned and clamped in position on the machine (with the boring bar between the centers) in such manner that the pivot pin C is exactly in the center of the pillow block or box. In starting a cut through the work, the cutter-head is rotated to the position shown by dotted lines at c (Figure 131). The tool a is then set to the correct radius and the cut started in the usual way without disturbing the position of the bar or work throughout the entire operation.

For boring the boxes and bearings of spheroidal journals or joints, commonly termed "ball and socket joints," the cutter-head is located and pivoted near the end of the bar, the tool

being rotated on its pivot by means of a shaft (which passes partly through the bar) and bevel gears connected on the shaft and cutter-head.

CHAPTER XIX.

Lathe Work.—*Continued.*

LINING UP LATHE SPINDLES.

The subject of setting a lathe to turn straight, and also of making the alignment of the live-spindle perfect, is one to which much importance is attached in every well-regulated shop.

There are many ways in which this can be accomplished. One method (which we have in our own practice used in preference to others) is shown in Fig-

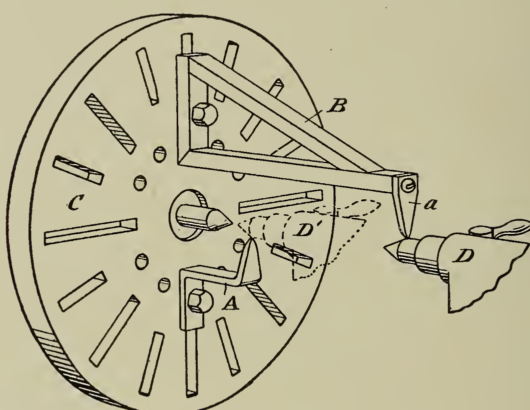


Fig. 135.

ure 135. It consists of two trams A and B, which are bolted to the face-plate of the lathe.

The short-armed tram A is made of iron or steel, and the long-armed tram B of wood with a steel pointer or needle a.

To set the lathe to turn straight, bolt the short tram A onto the face-plate C, then slide the tail-stock D along the shears until the centers almost touch (as shown by dotted lines at D′), then set the tram to touch on one side of the dead-center, when, by turning the face-plate, a glance will show which way to move the tail-stock to bring the center in line, and it will also show at once to what extent the live-spindle has dropped or worn down, if any.

To line up the live-spindle two trams must be used: first the short tram (as directed) and then the long tram.

It will be found that the spindles of any lathe can be set in line with great precision with these trams in the hands of a careful workman. And another thing in favor of their employment is that they can be made with very little trouble and are therefore always available when other and more expensive devices are not.

BORING AND TURNING WORK ON THE MONITOR CHUCK.

A large proportion of the work that is commonly chucked on the face-plate of the lathe has two or more surfaces (which stand at different angles) to be operated on. In most cases the horizontal axes of these surfaces stand on the same level, and would, if continued through the work, terminate or converge in one common center. Such work as this is generally chucked as though each surface to be operated on was an independent and separate part of the work. Sometimes the operations can be facilitated by making a series of chucks, especially for the work, on which it can be held in a different position as each surface has to be operated on, and in this way much time and labor can be saved and the work done more accurately; but in most cases in ordinary practice, the work is chucked either in an ordinary lathe chuck, or on an

angle-plate bolted to the face-plate of the lathe. But of the many excellent lathe chucks on the market, there are none capable of holding the work so that more than one surface can be operated on at one setting of the work in the chuck.

So long as the horizontal axes of the different surfaces of the work come on the same level and terminate in a common center (as explained above), there are two methods by which the work can be chucked and operated on at one setting. By the first method the work is set and bolted on a separate chucking plate, which is then boltd on an angle-plate to the face-plate of the lathe in such a way that one surface is in position for the operation; then when this surface has been operated on, the supplementary plate is loosened (without changing the position of the angle-plate on the face-plate), and the plate and work turned until the next surface is in position for the operation; the plate is then tightened up again and the operation proceeded with, and so on till the work is finished.

The amount of time and labor that can in all such operations be saved by this simple device is surprising, and as it is such as is available in every shop, there is therefore no excuse for employing a less efficient and more expensive method of doing the work.

By the second method the work is held on a special chuck which can be swiveled in such manner as to bring the different parts and surfaces of the work into position for the operation.

It would be impossible to find a chuck that is more eminently adapted to this purpose than the monitor chuck shown in Figures 85 and 86, which was specially designed for this particular class of work.

In Figures 87 and 88 the manner of chucking connecting-rod brasses and cross-heads for planing on the monitor chuck has been shown. It is now proposed

to show how this work is held on the same chuck for boring and turning.

BORING AND TURNING CONNECTING-ROD BRASSES AND CROSS-HEADS ON THE MONITOR CHUCK.

The next engraving, Figure 136, shows how the connecting-rod brasses are chucked for boring and turning on the same monitor chuck, A B representing the chuck bolted to the face-plate C of the lathe, D chuck-

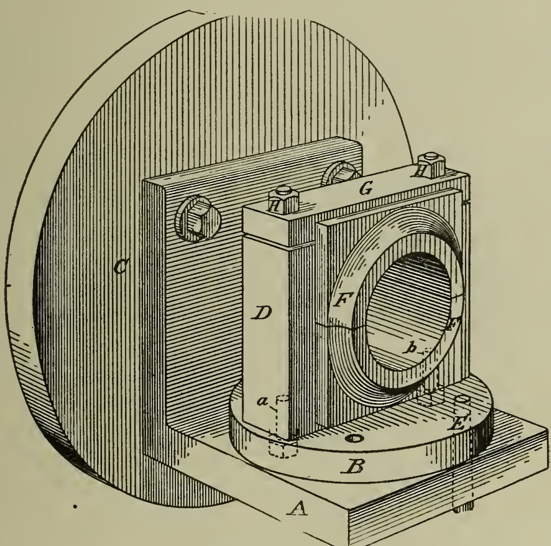


Fig. 136.

ing block bolted to the revolving plate B by the bolts a b (shown by dotted lines), F brasses held in the jaws of the chucking block D by the cap-plate G and bolts H H.

When the brasses have been bored, turned and faced on the front side, the chuck and work are turned

half way round, and the opposite side of the brasses brought into position to be turned and faced, thus completing the planing, boring, turning and facing at practically two operations and two chuckings, whereas, in ordinary practice, the brasses are usually chucked four times for the planing, and twice for the boring and turning.

Figure 137 shows a perspective view of a cross-head held on the monitor chuck for boring and turning for the cross-head pin (gudgeon) and piston rod.

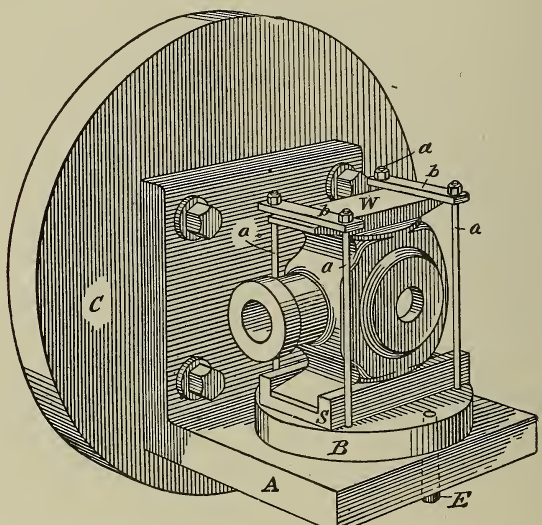


Fig. 137.

The cross-head or work W is located and held in a shoe S (which is doweled into the revolving plate B) by the bolts a a a a and straps b b. As shown in the figure, the work is in position for boring the holes for the cross-head pin.

Figure 138 represents a side and front elevation of a cross-head chucked in a similar manner on the same chuck. In this instance a cross-head of another type has been selected for two reasons: first, to show

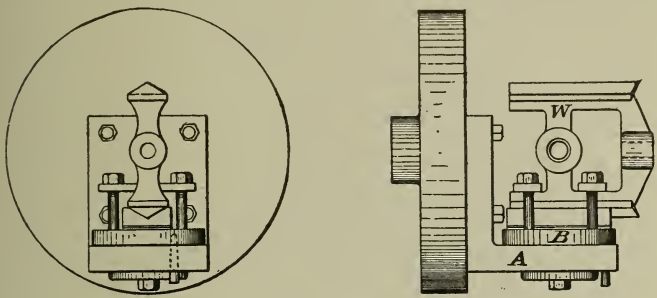


Fig. 138.

how the method of holding the work can be modified when the circumstances will permit, and, secondly, to show the position of the cross-head when boring the hub for the piston rod.

CHUCKING OTHER WORK ON THE MONITOR CHUCK FOR BORING AND TURNING.

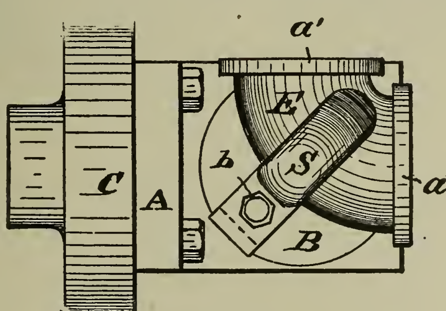


Fig. 139.

Figure 139 represents an elbow E held on the monitor chuck for turning the flanges a a′. The work is held on the chuck by means of the formed strap S

and bolt b. It is shown in position for turning the flange a.

Figure 140 shows the manner of chucking globe, gate, and check valves on the monitor chuck for the various operations thereon.

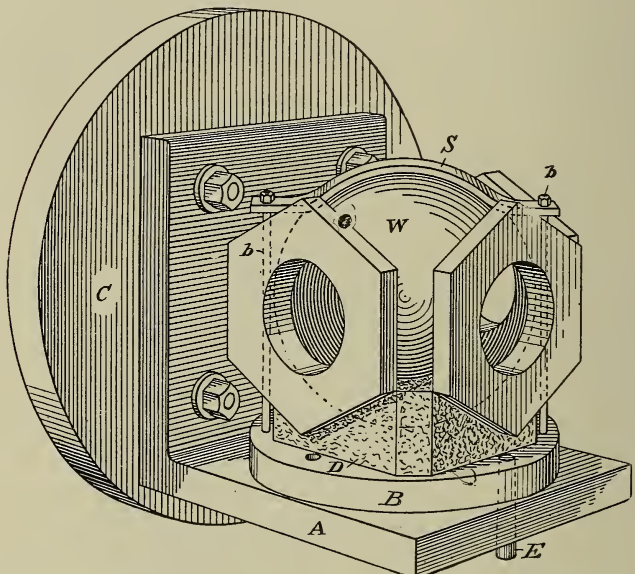


Fig. 140.

The work W is held by the strap S and bolts b b on a formed spelter base D, which is doweled into the revolving plate B.

Special chucking bases can be made of either spelter or babbitt-metal (or of lead either), for holding and aligning either regular or irregular shaped work on the revolving plate B, by banking around the work with prepared clay or molding sand (after the first piece of the work has been correctly aligned and set

on improvised supports on the revolving plate B), and then filling the space in the mold thus formed (between the chucking plate and the work) with the molten metal as far as desired; but before pouring the metal, the chucking plate B (and work) should be removed from the angle-plate A, to avoid cracking the latter by the expansion of the chucking plate as it becomes heated.

It will be readily seen that much of the work of a similar nature to that shown can be done at less cost, and to better advantage, on this or a similar chuck, than by other methods.

The face-plate C, shown in the foregoing engravings, is a plain one, and is therefore particularly adapted for holding special chucking appliances, as they can be doweled thereon, and so avoid the necessity of having to reset them every time they are removed.

CHAPTER XX.

Lathe Work.—*Continued.*

TURNING AND BORING PACKING RINGS.

The pistons and piston valves of steam engines, air and ammonia compressors, etc., are, with very few exceptions, packed with metallic (usually cast iron) packing rings, the making of which involves several processes of an interesting nature, and which are applicable to other classes of work.

The cylindrical casting (ring), from which the packing rings are (after turning) cut, always has lugs cast on one end by which it can be chucked to the face-plate of the lathe, to be bored and turned.

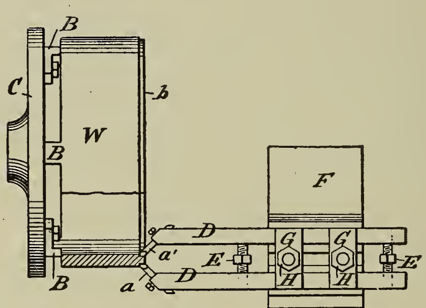


Fig. 141.

The turning and boring of the outside and inside diameters of the casting is in ordinary practice performed as independent operations. Figure 141 shows how the two operations can be proceeded with simultaneously, by employing two cutter-bars and tools. As

shown in the figure, W represents the casting (work), B B B the lugs and bolts by which it is held on the face-plate C, D D cutter-bars, a a′ tools, which are adjusted to the cut by means of the adjusting screws E E. The cutter-bars are held in a flanged plate I (which has a tongue J fitting into the T slot) on the tool rest F by means of the straps G G and bolts H H, the latter parts being shown to better advantage in the perspective view, Figure 142, where similar reference letters are employed to denote the same parts.

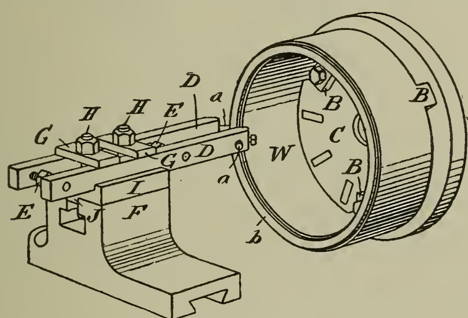


Fig. 142.

When the casting has been turned on the outside and inside, the face b (Figures 141 and 142) should be trued up. The rings are then cut off by means of an

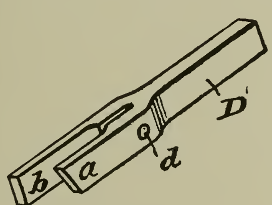


Fig. 143.

ordinary parting tool, or by employing either a solid or adjustable double-tongued parting tool, such as shown in Figure 143, the tongue a forming the parting

tool, and the elongated tongue b regulating the width at which to cut the rings off. The tool can be adjusted for wear by the adjusting screw d, Figure 144,

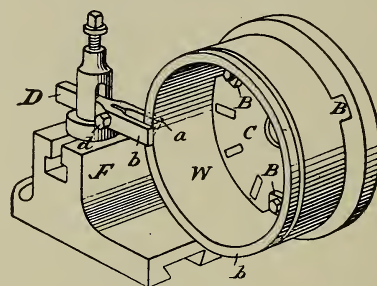


Fig. 144.

where the parting tool D is shown in operation.

When the ring has been cut off, the face b is again trued up and the operation repeated for the next ring.

A solid double-tongued parting tool is made the same as the adjustable tool (Figure 143) except that it is not adjustable.

The unfinished side of the rings can now be trued by chucking them on or in the jaws of an ordinary lathe chuck or an expanding chuck made for the purpose.

In turning packing rings they are always turned larger than the bore of the cylinder in which they are to work; the amount of which enlargement is equal to one-third of whatever metal is cut away in splitting the ring. The old-time practice of cutting a piece out of the ring in a straight line, but at an angle to the face of the same, and then springing it into the cylinder and filing down the high places until it fits the cylinder, has become obsolete. In modern practice the rings are cut as shown in Figure 145, where the full amount to be cut out is divided between the two sides of the ring, the part a being already cut out and the

part b marked off ready for cutting. When the ring is cut it appears, when open, as shown at A, and when closed, as shown at B (Figure 146). By this method, if the joint is well made, the ring is equal to a solid ring and will remain steam tight as long as it is in use.

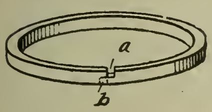


Fig. 145.

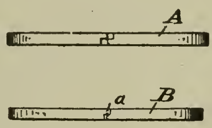


Fig. 146.

Instead of fitting the rings by hand filing as formerly, they are now turned to fit the cylinders, which is not only more expeditious, but more accurate.

In most shops when the rings have been split they are drilled and riveted together again at the joint (as shown by dotted lines at a [ring B, Figure 146]), which is done (for lack of a better means) to hold the rings together while they are being turned, a practice that is objectionable, inasmuch as it weakens the tongues of the joints and frequently causes them to crack or break.

A simpler way to hold the rings close together (and to obviate the necessity of riveting) while they are being chucked is to use a compression clamp, such as shown in Figure 147, the body B of which is made of thin band or sheet iron, to which two lugs a b are riveted; the clamp is tightened up by means of the bolt and nut c.

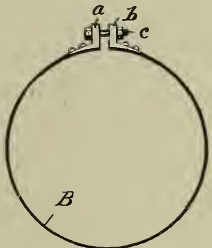


Fig. 147.

The rings are usually turned in pairs to fit the cylinder in which they are to work, and should be

held together while they are being chucked in the compression clamp, as shown in Figures 148 and 149, which represent a side and plan view of the clamp B and rings A A.

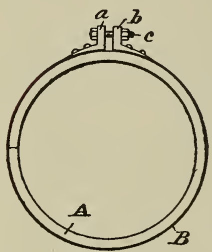


Fig. 148.

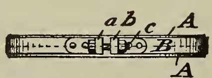


Fig. 149.

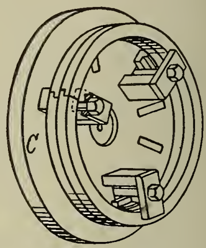


Fig. 150.

In turning an occasional pair of rings, they can be held in the clamp as shown above and then set true (by the inside) on the face-plate of the lathe; they are then bolted to the face-plate by three (or four) clamps, placing one clamp directly over the joint, as shown (by dotted lines) in Figure 150. A parallel or distance piece should be interposed between the work and the face-plate directly opposite each clamp to permit of the tool passing right across the face of the work without touching the face-plate.

When the piston head itself is of the compound form (which term embraces all forms except solid piston heads), the piston can be used as an arbor, and the rings turned therein by inserting a paper washer between the piston head and the rings to admit of the rings being tightened up sufficiently to hold them while being turned, clamping them together while chucking with the compression clamp.

When turning such rings in quantities, a chucking arbor (which somewhat resembles a piston), such as shown in Figure 151, is employed for holding the

rings. In the figure A A′ represents the arbor and fixed head, B B′ the rings, C adjustable follower-head, D nut by which the follower-head is tightened up.

This also represents the manner in which the rings are held for turning when chucked in the piston itself.

Sometimes packing rings are made thick on one and thin on the other side of their diameter, and then afterwards split on the thinnest side, on the supposition that when the ring is sprung into its place in the cylinder it will expand equally in all directions, thereby maintaining a true circle at all parts of its diameter. This form of packing ring has almost fallen into disuse now, as in practice they have not been found to give any better service than the ordinary form of packing ring, the thickness of which is the same at all parts of its diameter; in fact, it is thought in present practice that when the ring is of the same thickness throughout it is more serviceable, and for that reason the rings are, in modern practice, trued on the inside as well as on the outside after they have been split. In finishing an occasional pair of rings, if they have been chucked on the face-plate for turning the outside as already described, it is only necessary after turning the outside to transfer the clamps from the inside to the outside without disturbing the position of the work, and the rings can be turned both inside and outside at one chucking. But when the rings are made in quantities they are trued up in a special chuck (which is made to hold as many as desired) as shown partly in section in Figure 152, where A represents the rings (six in number), B B the chuck, C C, L

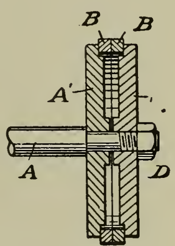


Fig. 151.

bolts by which the rings are held in the chuck, D D bolts by which the chuck is held on the face-plate E.

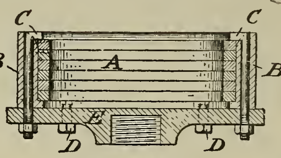


Fig. 152.

The compression clamp (or a modification of the same) (Figure 147) is also used for compressing the rings in entering the piston (with the rings inserted therein) in the cylinder.

TOOLS FOR EXPANDING THE LININGS OF BABBITTED BEARINGS AND COPPER-LINED PUMP CYLINDERS.

In all forms of babbitt-lined bearings an effort is always made to solidify and compress the babbitt-metal firmly to its place. Occasionally this is done by driving one or more drift plugs through the bearing, thereby enlarging the bore and compressing the metal, but on split and sectional bearings it is mostly done by hammering around the inner surfaces.

When the bearings are to be bored out the babbitted linings can be expanded to better advantage, and in a much superior manner with the tools employed for a similar purpose in expanding the inserted copper linings of pump cylinders. These linings are sometimes as much as one-quarter inch in thickness, and some idea can be had of the efficiency of the tools and methods employed in expanding the linings in the cylinders, when it is stated that after years of service the linings have to be cut out when it is necessary to remove and replace them with new ones.

In both cases the method of operating is precisely the same, and is as follows:

If the bearing or work is of such form that it can be chucked and revolved in the machine, the roller

tool, shown in Figure 153, is employed for expanding the lining; it is held in the tool post and fed through

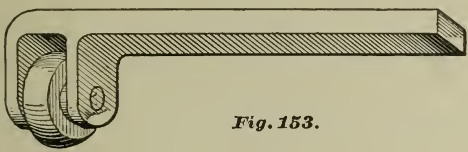


Fig. 153.

the work in the same way as a boring tool would be. But when the work is such that it has to be chucked stationary on the machine, and bored with a boring bar, the roller tool, shown in Figure 154 (which is the same as shown in Figure 74), is inserted in the bar or

Fig. 154.

cutter-head, and the lining expanded by that means, feeding the tool through the work the same as in boring.

CHAPTER XXI.

Lathe Work.—*Continued.*

SUPPORT FOR LIVE-SPINDLE.

It may be safely assumed that very little, if any, effort of a practical nature has ever been made in general practice to relieve the strains put on the live-spindle of a lathe in chucking heavy work on the face-plate. An attempt is often made to minimize the strains by placing a rod of iron or steel between the centers, which does not amount to very much at the best; and if the work has to be bored out, unless the bore is a large one, this method cannot be used at all, as the rod would be in the way of the boring tools. The only practical means by which this has been accomplished has been by placing roller bearings under the rim of the face-plate. On pit-lathe work, when boring and turning pulleys and gears of large diameter, we have on several occasions seen this done by placing two rollers of small diameter (journaled in a block of hard wood) under the rim of the face-plate and then blocking them up to take as much of the strain off the live-spindle as possible. On other occasions we have seen the same arrangement applied under the rim of the pulley itself, after a portion has been turned.

A simple arrangement employed for the same purpose, but of a more substantial character, is shown in

Figure 155, which consists of two roller bearings A A′ journaled in the brackets B B′, which are adjustable on the saddle block E by means of the adjusting

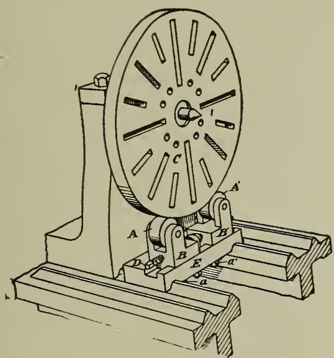


Fig. 155.

screw D. The roller bearings are adjusted to the rim of the face-plate C before the work is chucked thereon, the adjusting screw having a right and left hand thread on its respective ends.

When the rollers have been adjusted, the brackets B B′ are fixed to the saddle plate E by the binding screws a a′. This device will be found to be of great assistance in turning and boring heavy work on the lathe, and will not on ordinary work interfere with the movements of the lathe carriage. It may, however, be necessary to modify the construction somewhat to suit individual cases. As the face-plate is on such work, always revolving at a slow speed, it will be a considerable time before any perceptible wear occurs on the rim.

EXTENDING THE DIAMETER OF A FACE-PLATE.

It is sometimes necessary to bore and turn an occasional piece of work (such as a large pulley or gear wheel) on the lathe that needs to be chucked on

a face-plate of large diameter, and that a face-plate of such dimensions is not available for the job. In such cases, instead of chucking the work on blocking interposed between the arms (or other parts) of the work and the face-plate, the capacity of the face-plate should be increased to suit the work, which can in most cases be done in a very simple manner by employing the means already at hand, an instance of which is shown in Figure 156, where the diameter of the

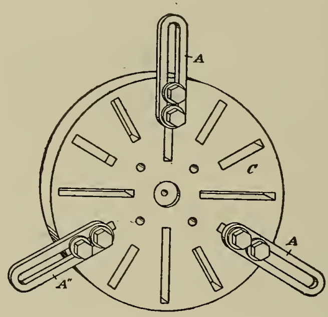


Fig. 156.

face-plate C has been increased by bolting three common link-straps A A′ A″ thereon, the work being bolted to the straps instead of the face-plate.

SLIDING LATHE CHUCKS.

One of the oldest forms of lathe chucks is the sliding face-plate chuck, which in all probability originated from the "Jewelers' eccentric chuck," of which a description was published in the "Mechanics' Magazine" (London, Oct. 18th, 1823).

This form of chuck has been employed in one of the largest railway shops in England for more than thirty years, for holding eccentrics, pulleys, small cranks and a variety of similar work while being turned.

There are two distinct forms of these chucks. One form is employed extensively as an adjustable chucking arbor for holding such work as that mentioned above, and the other form is used for holding templates, jigs, die-plates, and other work of a similar nature (in addition to holding the work specified above) that has to be accurately spaced and bored.

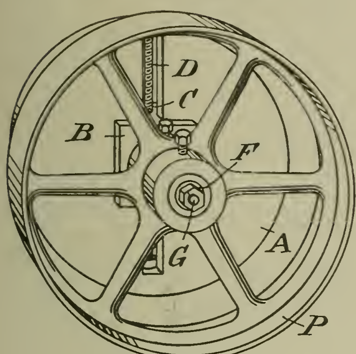


Fig. 157.

Figure 157 represents the first form of these sliding chucks with a pulley P chucked thereon in position for turning. In construction the chuck consists of a body A, a sliding head B threaded at C to fit the adjusting screw D. The hub E is threaded to fit the nose of the live-spindle of the lathe in the same manner as other chucks. The arbor F (shown in Figure 158, which represents a sectional side view of the chuck and work) is made of small diameter, and is threaded on the outside to receive the threaded bushings which are made of various diameters to fit the bores of the different classes and sizes of the work. The arbor is, when once set, held in position by the binding screw G.

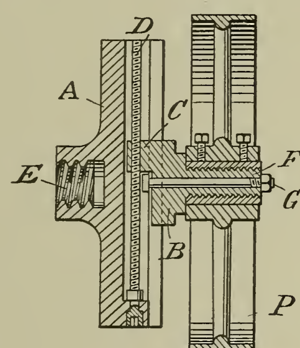


Fig. 158.

Figure 159 shows the second form of sliding lathe chuck, with an eccentric chucked on the arbor ready for turning. In construction this chuck consists of a base A, a sliding chucking plate (which for convenience will

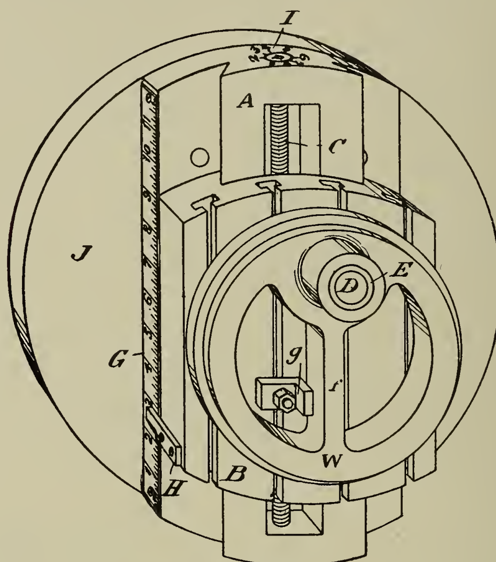


Fig. 159.

be designated as chuck) B, which is adjusted by means of the screw C. The work (eccentric) W is held on the arbor D, the diameter of which has been increased by the bushing E to fit the bore of the work which is held by the set screw F (shown in Figure 160).

To facilitate the operation of setting the chuck or work, the base A is graduated by fastening an ordinary steel rule or scale on the side, as shown at G, the indications being read by means of the index finger H; the sub-divisions are more accurately read by means of the graduations I on the end of the

screw C. The base A is doweled in the faceplate J by the dowel-pins a a′, and is held in position by the bolts b b, Figure 160, which represents a sectional side view of the chuck and work. The arbor D is screwed into the chuck B, as shown at c, and can be removed when not required.

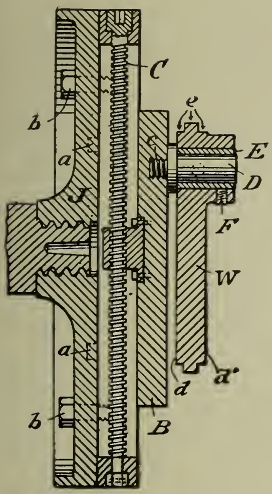


Fig. 160.

When turning eccentrics on this chuck, the eccentric is first bored to size and the hole drilled and tapped in the hub for the set screw F, which admits of the eccentric being held on the arbor while it is being turned in precisely the same way as it is held on the crank-shaft or axle of the engine, thereby avoiding the tendency to spring it out of true after it is turned, which often happens when it is held for turning by other means.

The sides d d′ of the eccentric are always turned before the crown e (Figure 160) is finished.

It is always difficult to hold eccentrics of large diameter while turning their outer surfaces, if they are held on the arbor by the set screw alone, as the strain exerted by the cut is very considerable at certain points of the work; but, as such eccentrics are in most cases made as shown in Figure 159, this strain can always be equalized by bolting a stop-pin or carrier g against the arm f, as near as possible to the outer diameter of the work.

When the chuck is used for spacing the holes in die-plates or for other work as mentioned above, the

work is held on the chuck B, as shown in Figure 161, which represents a front elevation of the chuck only with the work W clamped thereon.

On die-plates the holes nearly always come in straight rows which run either lengthwise or crosswise of the work.

On jig or template work the holes may be what is termed "staggered," that is, they may be located anywhere on the jig or template, but it is always possible to set the work on the chuck in such manner that two or more of the holes can be brought into position for the boring at one setting by sliding the chuck and work across the face-plate.

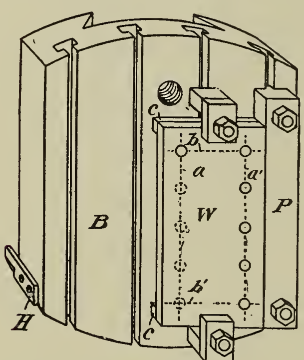


Fig. 161.

Before laying out the work it should be machined and finished to size all over; the upper surface is then "coppered" with the ordinary blue vitriol solution, and the parallel lines a a′ drawn lengthwise of the work, to indicate the centers of the holes in that direction; similar lines b b′ are then drawn transversely across the work to indicate the centers in that direction also.

In ordinary practice the work would then be spaced and laid off in circles as shown by dotted lines in the figure on the left row (the row on the right being already bored, and also the first hole of the left row), but in this case it is only necessary to lay off the parallel lines a a′ to set the work by on the chuck, and the transverse lines b b′ to indicate the center of the first hole of each row. The work is then set on the chuck by means of a tool such as shown in

Figure 162 (blocking it out from the face-plate by the parallels c c), in such manner that as the chuck and work are moved across the face-plate the line a will be coincident with the axial line of the lathe spindle; at every point of its movement, the holes are then spaced by means of the measuring screw C (Figures 159 and 160), not depending on the measuring screw alone to determine the correctness of the divisions, but gauging the accuracy of the same by

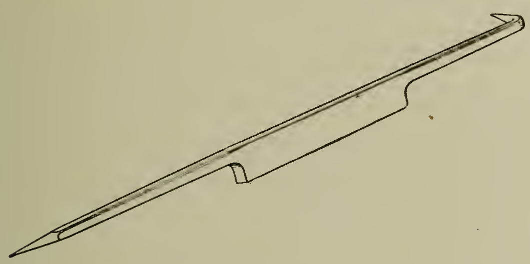


Fig. 162.

means of calipers; the best form for this purpose being the kind termed "odd-legged calipers" (of which a description will be hereafter given), by means of which the slightest possible variation can be readily detected.

If the T slots of the chuck are planed parallel with the slides of the chuck and are all of the same width, the work can be more easily and correctly set by having a tongued parallel P (made to fit into the T slots) against which one side of the work can be set, and which will ensure the correct alignment of all the holes which happen to come on that row. And in such cases as that shown in the figure, where the opposite row a′ of holes is exactly the same distance from the edge of the work as the row a (a case in

point which frequently occurs in practice), it is only necessary to turn the work end for end (which has already been done in this case), and this row of holes is in position to be bored.

When there are intermediate rows of holes to be bored, the position of the work is changed to bring such holes into line, by changing the parallel P from one slot to another, or by interposing other parallels of standard thickness between the work and the parallel P in an obvious manner.

On die-plate and similar work that requires to be spaced with great precision, and which has to be hardened after the holes are bored, it is best to bore all the holes a trifle below size, say two or three one-thousandths of an inch, and then after the work has been hardened (which is sure to change the position of the holes somewhat) to re-chuck it in the same manner as before, and then grind the holes to size. This is about the only practical method by which the holes in hardened die-plates and similar work can be correctly sized and spaced.

On jig and template work the same principle of chucking is followed but is modified to suit the circumstances.

CHAPTER XXII.

Lathe Work.—*Continued.*

TURNING CURVED SURFACES.

The turning of external curved surfaces can be accomplished either with or without special appliances. When turned without any special appliance the work is held and driven in the ordinary way, and the position of the tool is changed by hand as it is fed across the surface of the work by the carriage feed in such manner that the work is turned to fit a template made for the purpose. This is not what might be called "good practice," but if there is only one or a few of such pieces to be turned, it is the best that can be done under the circumstances, as in all probability it would not pay to rig up any contrivance, however simple, just for this particular job.

When the work is done by means of special appliances, the nature of such appliances depends entirely on the form of the surface to be turned, that is, whether the surface of the work would represent a true circle (ball or sphere) or the arc of a circle (as in turning what is termed a "crown-faced pulley"), or is merely curved (as in turning the body of a car axle).

Formers are usually employed for turning curved surfaces and may consist of a plain or slotted former bar, or grooved former guide (attached to the slides or other parts of the lathe according to the construction of

the lathe or the space in which the tool has to operate), and an arm or bracket extending from the tool rest to the former with which it is connected by means of a roller or rollers in such manner that the position of the tool point is continually changed as it is fed across the surface of the work.

Figure 163 represents an appliance which is used for turning the curved body of a car axle.

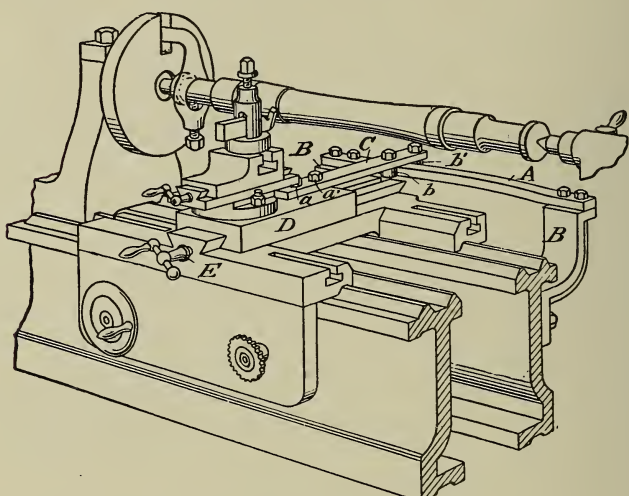


Fig. 163.

The curved former bar A is bolted on the brackets B B which are held on the lathe bed; the arm C is held on the base D of the compound slide rest by the bolts a a′ and is connected with the bar A by the rollers b b′, the cross-feed screw E being disconnected from the tool rest altogether.

It will be seen that as the tool is fed along the work it is moved in or out, thus conforming the surface turned to the shape of the former bar.

Figure 164 represents a similar device employed for turning "crown-faced pulleys."

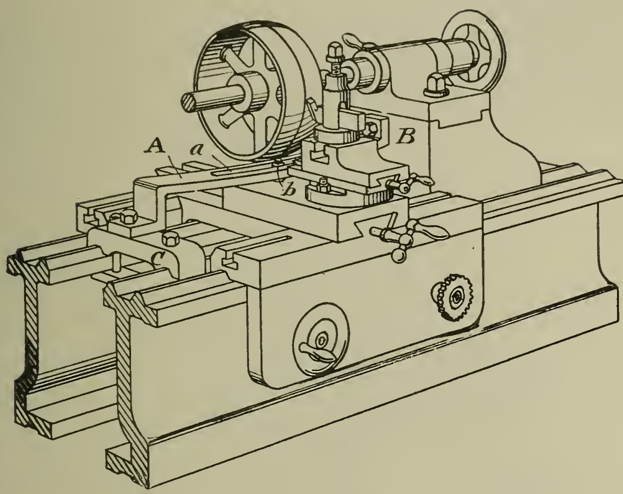


Fig. 164.

In this case the former A is bolted on the one end to the tail-stock B of the lathe, and on the other end to a saddle plate C located on the inner V's of the lathe bed. A slot or guide groove a extends along the center of the former A; in this slot the roller b (which is attached by a stud bolt to the base of the tool rest) works. The cross-feed screw is disconnected and the tool operated the same as in the preceding example.

The larger types of lathes which are designated in the machine shop as "Bull Lathes" usually have what is termed a "double slide compound tool rest," the two upper slides being intended to relieve the lower slides which are too heavy to be operated with the same ease and facility as the upper slides (except on long, heavy cuts), and also to admit of taper surfaces being turned.

On this class of lathes there are two methods of fixing a former on the lower auxiliary slide for turning curved work, as shown in the following Figures 165 and 166.

In Figure 165 the former A is fitted to the base a of the auxiliary slide B, and is bolted thereto in such manner as not to interfere with the working of the

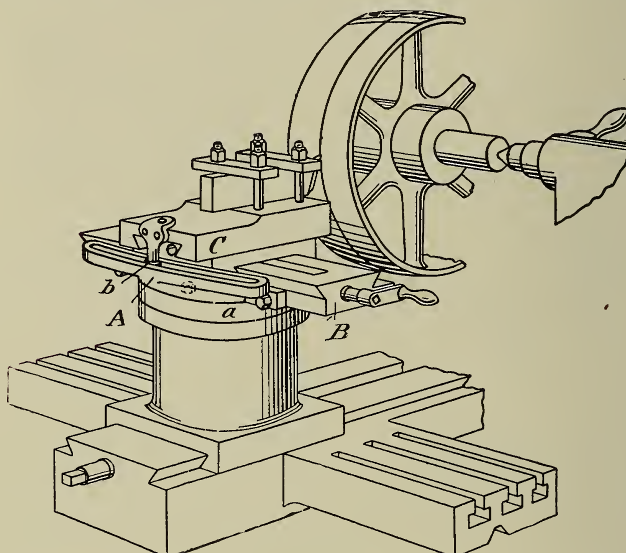


Fig. 165.

slide rest; the roller b is screwed on the end of the upper auxiliary slide C, the feed screw of which has been removed.

In Figure 166 a similar former A and roller b are employed for the same purpose and are held on the lower auxiliary slide, which is in this case turned crosswise of the lathe carriage. The tool is fed across the work by means of the upper auxiliary slide.

This method of fixing the former on the slide is only resorted to when the space in which the tool has to operate is insufficient to admit of the lower auxiliary slide being placed lengthwise of the carriage (as in the preceding example), as it is only possible to turn narrow surfaces by this means, on account of the limited movement of the upper auxiliary slide, which movement seldom exceeds nine inches.

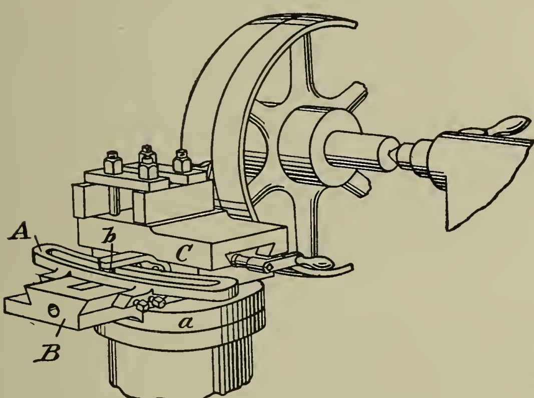


Fig. 166.

Whenever formers are employed in the above manner, the curvature of the former should be exactly the same in the center of the groove or bar as that required for the surface of the work.

When used on a lathe having only a single auxiliary tool rest (as in Figures 163 and 164), the tool is adjusted to the cut by the auxiliary slide rest which is set parallel with the regular cross-slide and is fed across or along the work by the regular carriage feed. And when used on a lathe having a double auxiliary slide rest (as in Figures 165 and 166), the tool is adjusted to the cut by the regular cross-slide feed screw,

and is traversed across the surface of the work by either of the auxiliary slides according to the manner in which the former is arranged on the lower auxiliary slide.

Sometimes the auxiliary slides are operated by power, but in most cases they are operated by hand—a case in point in machine-shop practice which is neither advisable or necessary, as there is in every instance (without any exception whatever) several simple and inexpensive methods by which either or both slides can be operated automatically.

A hand-fed tool is never as efficient or economical as a machine-fed tool, for under the most favorable circumstances the hand-fed tool is always irregular in its action, and consequently the results are seldom as satisfactory as when a positive feed is employed.

SPHERICAL TURNING.

All tools for spherical or (as it is commonly termed) "ball" turning operate on the same principle, which is that of a cutter-head, tool rest, or equivalent appliance, whose vertical axis is coincident with the axis of the ball or sphere to be turned, or, what amounts to the same thing, with the axis of the live-spindle of the lathe or machine, and which is capable of being rotated on its pivot or axis in such manner that a tool fixed in the cutter-head or tool rest, with its point or cutting edge exactly on the same level as the lathe centers, will, when set at any distance from the axis of the work, describe a true circle or arc around the same, whose radius, when measured from the axis of the work, will be the same at every point of its circumference, thereby producing (when the tool is adjusted to the cut, and the work is revolving in the ordinary way, and the cutter-head or tool rest is rotated on its axis [pivot] as described) a true sphere

whose diameter measures the same at every point of its circumference.

Figure 167 represents one form of tool rest for

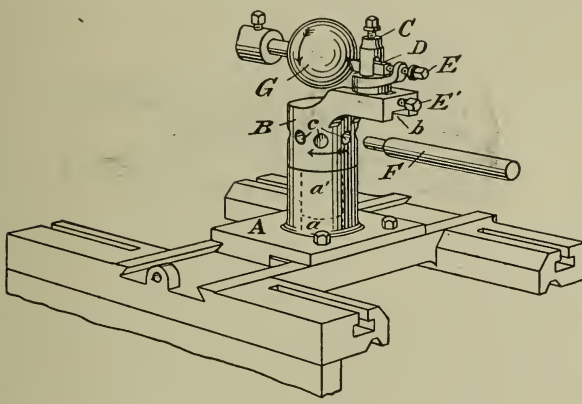


Fig. 167.

spherical turning, with the ball G and tool D in position for the operation. In construction the rest consists of a base A, dove-tailed on the bottom to fit into or over the cross-slide of the lathe carriage, and bored at a to receive the pivot pin a′ of the tool rest B which is slotted at b for the tool post C; the tool D can be adjusted sufficiently for all practical purposes by means of the adjusting screw E and set screw E′; the body of the rest is drilled at c for the insertion of the lever F, by means of which the tool rest and tool are rotated (fed) around the work as it revolves in the lathe or machine.

On smaller lathes the base A is fitted directly on the lathe bed, which can also be done on the larger lathes when desired.

The tool rest B can be fitted with a slide for adjusting the tool in place of the slot b, if preferred.

For turning brass and other soft metal balls of small diameter the above is an excellent appliance; but for iron or steel balls of any diameter a revolving sliding tool rest should be employed.

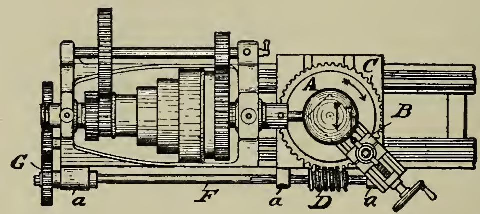


Fig. 168.

Figure 168 represents a sliding tool rest for spherical turning. A base plate (not shown) is fitted onto the cross-slide ways of the lathe carriage, then upon this base plate is fitted the base A (of the tool rest B) which is circular in form, and is geared at C to engage with the worm D. The worm shaft F is journaled on the lathe carriage in the brackets a a′, and on the lathe bed in the bracket a″, and is actuated from the screw-cutting gears G. The method of operating is so clearly shown in the engraving that further explanation is thought to be unnecessary, except to touch upon the two most important points, viz.: First, the imperative necessity of having the vertical axis of the work and the pivot pin of the tool rest coincident, and, secondly, of having the point or cutting edge of the tool exactly level with the horizontal axes of the lathe spindle and work.

If there is any divergence from a true coincidence in either case, the ball would not be turned a true sphere, but would be oval to just twice the extent that the tool rest, or tool point, are out of a true alignment.

CHAPTER XXIII.

Lathe Work.—*Continued.*

TURNING AND BORING PULLEYS.

Turning and boring pulleys is one of the most common operations in the whole range of machine-shop practice, and for that reason is a part of the work in which every machinist is interested.

In many shops pulleys are made in such quantities that special machines are employed for their production. Sometimes the chucks in which the pulleys are held for boring are made self-centering, thereby avoiding the necessity of having to set the work every time another piece is chucked. Considerable ingenuity is displayed in the design and construction of some of the chucks employed for this purpose, and when they are employed in connection with other self-locating and operating tools, the work can be performed by unskilled help, as in such cases there is no measuring to be done, and no setting of the work, and nothing to get out of place, the tool maker or the supervisor keeping everything in order and supervising the work in general.

In most shops, however, the pulleys are held in an ordinary lathe chuck or bolted to the face-plate of the lathe for boring, and are turned between the lathe centers on an arbor or mandrel which is driven tight into the hub, a practice which necessitates the employment of a separate mandrel for each size of pulley bore, except

in those cases where the mandrel is made extra long, and is turned to fit two or more bores.

It is not always an easy matter to drive the mandrel into the pulley tight enough for turning, or to remove it again after the pulley has been turned, and it not infrequently occurs that the pulley arms are cracked or broken in driving the mandrel in or out. Therefore, when a mandrel is used for this purpose at all, a better and safer way is to use one that is made a good sliding fit in the hole (bore), which can be inserted and removed more expeditiously without having to be driven either in or out. Small pulleys and solid and webbed pulleys (pulleys in which the rim is joined to the hub by means of a web or webs) are turned on a mandrel such as shown in Figure 169, where A A′

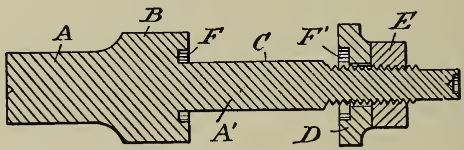


Fig. 169.

represents the mandrel turned at C to fit the bore, and enlarged to form a head at B, against which the hub of the pulley is held by the loose washer D and jam nut E, the work being held and driven as shown in Figure 170, which represents a small flanged pulley P chucked by the bore on the mandrel A and held between the centers of the lathe ready to be turned; the head of the mandrel and the washer are recessed at F F′ to afford a better contact for holding the hub of the work.

When used for turning small work, the mandrel is made of iron or steel, but for larger work it can be made of cast iron and should have a hardened steel

center inserted in the end which revolves on the dead-center of the lathe.

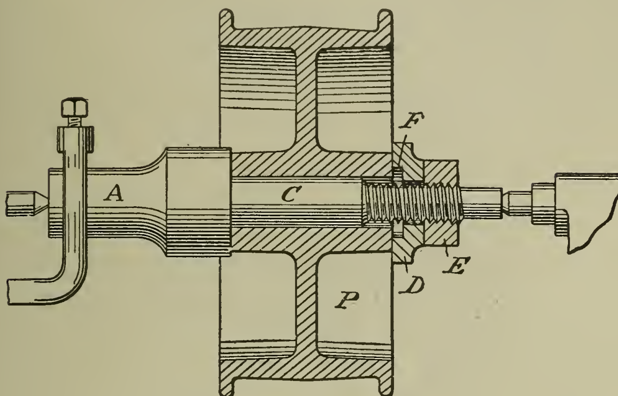


Fig. 170.

For turning heavier and larger pulleys it is best to use cast-iron mandrels altogether, as they cost less to make and are harder and more durable than wrought iron.

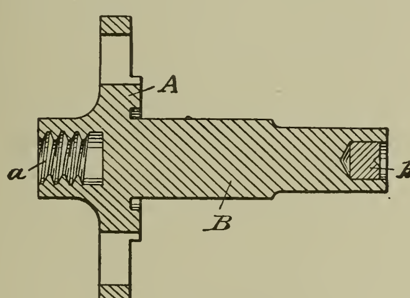


Fig. 171.

Figure 171 represents an improved form of mandrel for turning pulleys and similar work. It is made in one piece with a hub or head A (which in form re-

sembles a small face-plate) threaded at a to fit the nose of the live-spindle of the lathe, and a stem B which forms the arbor turned to fit the bore of the work, which is held or chucked thereon, as shown in Figure 173.

Figure 172 represents a mandrel of the same type

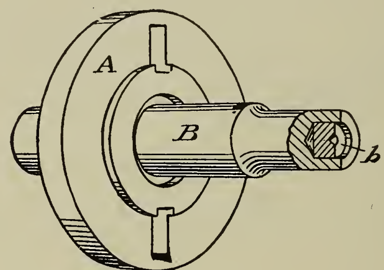


Fig. 172.

as Figure 171, but modified so that the work, though held thereon in the same manner, can be turned between the centers of the lathe. In each case a hardened center b is inserted in that end of the mandrel which turns on the dead-center.

Figure 173 shows the manner of chucking the pulley on the mandrel in both cases. As shown therein, the work P (pulley) is held between the centers c c′ of the lathe on the mandrel (shown in Figure 172) B by the link strap d and bolts e e, which draws the pulley hub up to the head A. To assist in driving the work a pin-dog or carrier f is employed in the head A in the usual way.

When the body B is made to fit the bore of the work as it should, mandrels of this type are better than any other kind, and especially is this true of the type shown in Figure 171, which is far superior to anything else of the same character.

It might be possible to make the body B to fit a smaller sized bore, and then to enlarge its diameter by

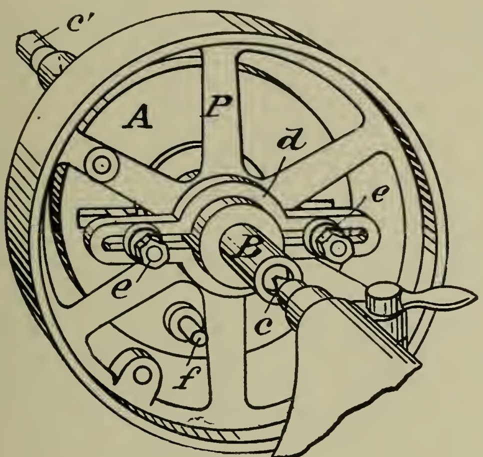


Fig. 173.

bushing for larger bores, but as we have not seen this tried, it is merely offered as a suggestion.

SIMULTANEOUS PULLEY BORING AND TURNING.

The most economical and expeditious way to turn and bore pulleys in the lathe is to perform the two operations simultaneously. The outfit required for doing the work in this manner is of a very simple and inexpensive character, and is such as can be applied to any lathe large enough to swing the pulleys above the shears. The outfit required consists of a special chuck, on which the pulley is held by the arms, A boring bar, and, when necessary, a bracket for guiding and steadying the boring bar. There are two kinds of chucks employed for this purpose: one kind consists of three separate chucking jaws or brackets which can

be bolted on the face-plate of the lathe, in the position best suited for holding the work; the other kind consists of a chucking ring which can be set and bolted on the face-plate. In this case three chucking jaws or brackets, similar to those mentioned above, are cast on the ring, as shown in Figure 174,

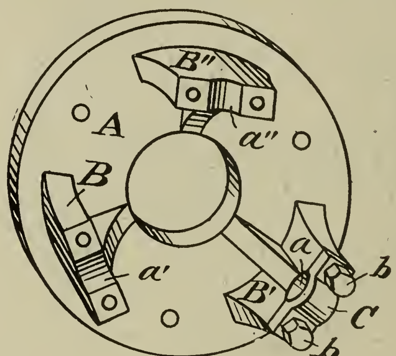


Fig. 174.

where A represents the ring or base, B B′ B″ the brackets, C cap; the brackets are provided at a a′ a″ with a recessed bearing or jaw to receive the arms of the pulley, which is then held in position by a cap C on each bracket. The application of this form of chuck is restricted to the holding of pulleys having six arms, but it can of course be arranged for holding pulleys having any other number of arms, an objection which does not exist when independent chucking brackets are used as mentioned above.

To perform the operations of boring and turning simultaneously, the work (pulley) is chucked as shown in Figure 175, where P represents the work held on the chuck (Figure 174) A by the caps C C′ C″, D face-plate to which the chuck and work are bolted, E boring bar, broken away at a to show the turning

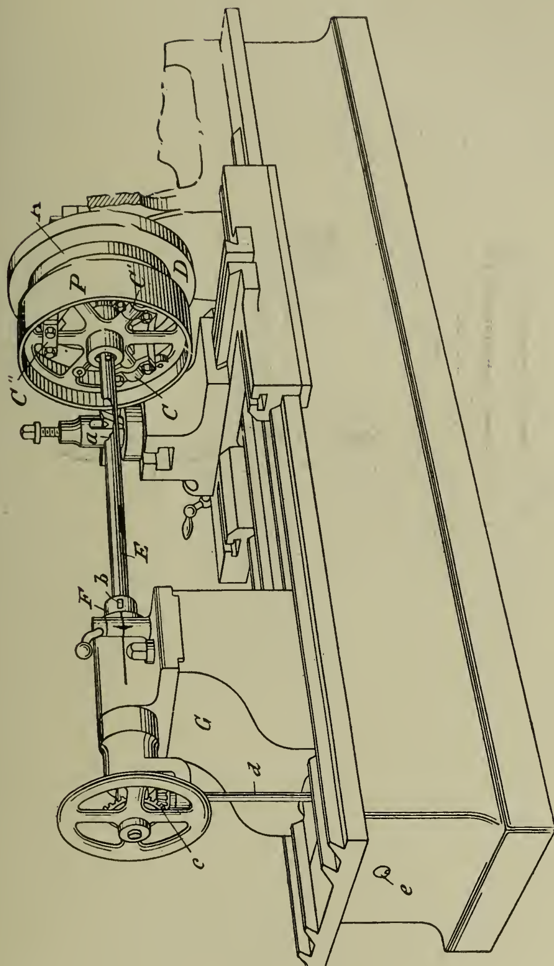


Fig. 175.

tool, and keyed at b into the tail-spindle F, which is (in this case) provided with an automatic feed by means of the bevel gears c, which are driven by the shafts d and e, the shaft d being journaled in suitable bracket-bearings attached to the tail-stock G; the shaft e is driven by gearing (not shown) on the head end of the lathe.

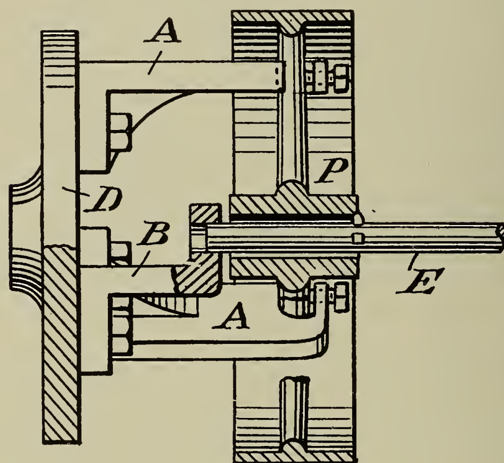


Fig. 176.

In this case the live-spindle of the lathe is supposed to be a hollow one, which furnishes a means for guiding and steadying the boring bar on the head end of the lathe, thereby admitting (as will be seen) of the simultaneous performance of the two operations (boring and turning), with no extra appliances or special fixtures but the chuck A and boring bar E. In setting the pulley in this chuck a narrow strip of leather is interposed between the arms of the pulley and the chuck jaws, to avoid springing the work.

For holding pulleys below twelve inches, a small chuck is used, but for holding pulleys whose diameter exceeds twelve inches, one chuck can be made to hold any pulley from twelve inches to five feet in diameter. Above that size it is best to use single (independent) chucking brackets, such as shown in Figure 176, where the work (pulley) P is held on the brackets A A (one of which has been removed), which are bolted on the face-plate D.

In this case the work and appliances are represented partly in section in order to show the method employed for simultaneous boring and turning when the live-spindle of the lathe is a solid one and cannot be used for guiding and steadying the boring bar, which must therefore be done by other means. The method shown in the figure represents that employed for boring and turning light pulleys of small diameter, say below eighteen inches, the work being held on the brackets A A at a distance from the face-plate which will admit of the employment of a guide bracket B interposed between the work and the face-plate for guiding and steadying the boring bar E while the pulley is being bored.

For boring and turning heavier and larger pulleys simultaneously, or when it is desired to perform the two operations independently, as in ordinary practice, but at one setting and chucking of the work, it is not good practice to chuck the work further out from the face-plate than is absolutely necessary. When the operations are performed in the ordinary way, the guide bracket B and boring bar E are not used, and consequently the work can be chucked closer to the face-plate, which is done by making the brackets A A as much shorter as desired. This is also done with larger and heavier work when it is desired to perform the two operations at the same time, the bracket for guiding the boring bar reaching through the arms of

the pulley to the outside of the hub, as shown in Figure 177, where similar reference letters denote the same parts.

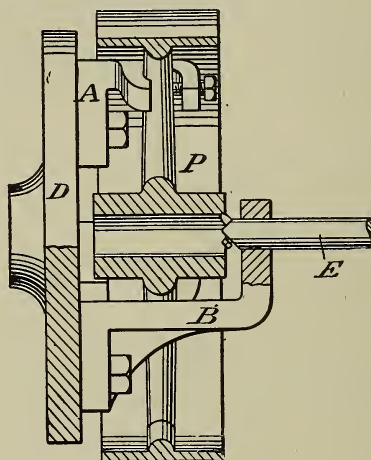


Fig. 177.

Ordinarily the boring bar is fed through the work by hand, but there are several simple methods by which the tail-spindle of the lathe can be made to feed automatically.

CHAPTER XXIV.

Lathe Work.—*Continued.*

TURNING CRANKS.

There is not a more instructive or interesting series of processes in the whole range of machine-shop work than those involved in the turning and making of solid and built-up cranks (the latter term applying to all forms of cranks which are made or built up in sections, regardless of the purpose for which they are used). Turning the pin of a solid crank is at all times a difficult operation, on account of the distance at which the tools have to extend (unsupported) from the tool-post, and the difficulty experienced in chucking and retaining the crank-shaft in position for and during the operation. Usually the crank-shaft is chucked or held directly between the lathe centers, the body (or shaft) being offset to the amount of the crank's throw. It is therefore an impossibility to use the ordinary speeds and feeds under such circumstances; for if such were to be employed, the tool would dig into the work to such an extent as to throw it out of the centers, or otherwise spoil it by turning a deep groove therein, to remove which the pin would have to be turned below the diameter required.

In Figures 178 and 179 is shown a method of turning solid cranks whereby the above objections are almost (if not entirely) removed. In this case, instead of holding the crank-shaft between the lathe centers in the ordinary way, one end of the shaft is clamped firmly in a V block which is bolted to the face-plate

as shown in Figure 178, where W W represents the crank-shaft in position for turning the pin, supported

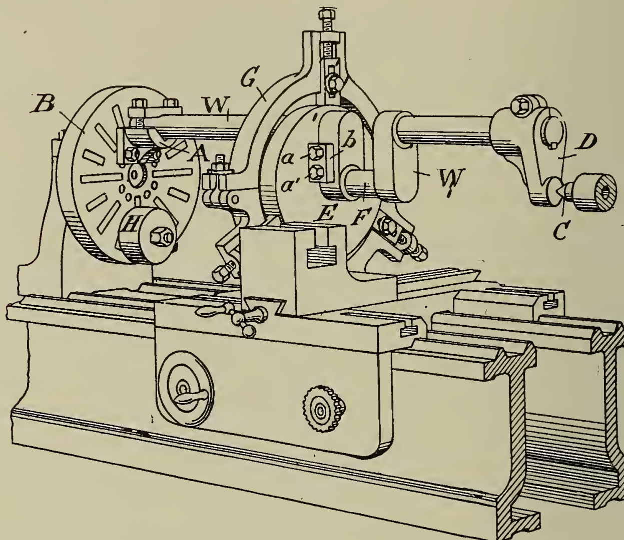


Fig. 178.

on the one end in the V block A on the face-plate B, and on the other end in the usual way on the center C, by means of the crank-block D. In turning very heavy crank-shafts which would not be likely to be sprung of their own weight and in tightening the dead-center C up this method is usually sufficient for holding the work while the pin F is being turned. But in turning the pins of crank-shafts that are more slender in construction, and which would be certain to spring (if not of their own weight) when the center is tightened up, the shaft should be supported in an entirely different manner, in fact the dead-center should only be used as an auxiliary support, or as an

additional safeguard to prevent the work from twisting in its supports. This is accomplished by employing an eccentric E (whose throw is twice that of the crank) in the manner shown. The eccentric is bored to fit the body of the crank-shaft, and can be adjusted in an obvious manner concentric with the crank-pin F by means of the set screws a a′ in the lugs b, which are cast on the eccentric for this purpose. When the eccentric has been correctly set, it is journaled in a steady-rest G in the ordinary way.

The crank-center block D is shown keyed on the shaft, which furnishes another excellent means of securing the precise location of the crank-pin and key-seat when such is desired for the purpose explained elsewhere. The weight H is bolted to the face-plate to counter-balance the work and attachments. By the above arrangement, one of the most serious difficulties of crank-shaft turning is overcome. The next and really the most serious difficulty of any is that of the overhanging tool. This is also readily overcome by the method shown in Figure 179, where the tool T is shown supported on a narrow bracket I which is fastened to the tool-rest J; the tool is drilled on the under side at c′ for the reception of the dowel-pin c, which prevents the tool from moving sideways under a heavy cut. The thickness of the bracket I is made slightly less than that of the tool.

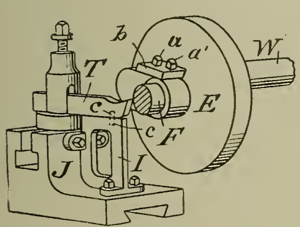


Fig. 179.

In turning the shaft itself, it is supported in a steady-rest which is applied in the same relative position as shown in Figure 178, but journaled directly on the shaft, after a portion has been turned for that purpose.

The construction of a built-up crank calls for the following important operations: Making sliding, working, driving and shrinkage fits, these operations practically constituting in some form or other the whole principle of turning and boring.

The first operations consist in roughing out the shafts and discs, then in turning the ends of the shafts to fit in the hub of the discs. The holes in the discs are always bored (and sometimes reamed) to standard size, making the allowance for the driving fits on the shafts. There is no definite rule for determining the exact allowance to be made for driving fits, and where such rules are given, they are always arbitrary and consequently are only adapted for the work and under the conditions for which they were made. A good rule to follow for general purposes is to make the shaft $\frac{1}{1000}''$ larger than the hole into which it has to be driven, but this allowance may have to be increased or decreased according to the requirements, which are governed by the following conditions: The amount of metal around the hole, the length and diameter of the same, and the force available for driving the shaft therein.

The crank-discs are either chucked on the face-plate or held in an ordinary lathe chuck to bore the hub for the shaft and to rough off the outside, and then, if desired, while the disc is still in position, the hole for the crank-pin can be roughed out to near the finished size by means of the boring attachment shown in Figure 124, but in most cases the discs are chucked separately to rough out the pin-hole.

The method of chucking the discs for the above operations is shown in Figures 180 and 181, which represent a front and side elevation (partly in section) of the crank-disc A chucked on the arbor B to the face-plate C, in position for the operation. When the first disc has been set on the chuck ready for the

operation, a stop-plate E is bolted to the face-plate in such a manner as to abut against the boss D, thereby serving as a means for locating all the subsequent discs to be operated on. The crank-pin hole is never bored to size until after the disc is keyed on the shaft.

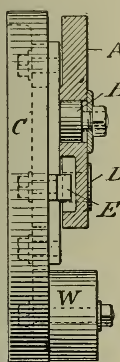


Fig. 180.

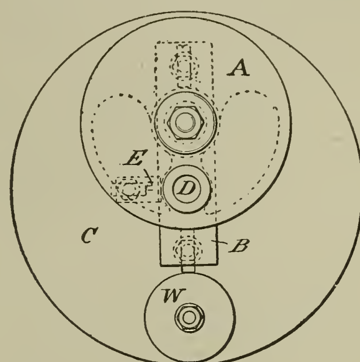


Fig. 181.

When the shaft has been turned and the disc bored, the shaft is driven (or pressed) into the disc and keyed in place; it is then put into the lathe and the front (pin) side of the disc finished to size.

The shrinking together of a double built-up crank, such as the one under consideration, furnishes one of the best examples obtainable for describing the requirements for making shrinkage fits in general, inasmuch as the action occurring during the shrinking process, and the permanent disposition of the metal (in cooling off), can be very accurately followed and traced.

Figure 182 represents a double (center) built-up crank shrunk together by a process to be hereafter shown. When the holes for the crank-pin are bored parallel with the axis of the shaft, and the ends of the bosses are faced at right angles to the same, and the

crank is shrunk together, as in ordinary practice, the crank will, when placed between the centers of the lathe, be found to be out of true at the points c c′ to

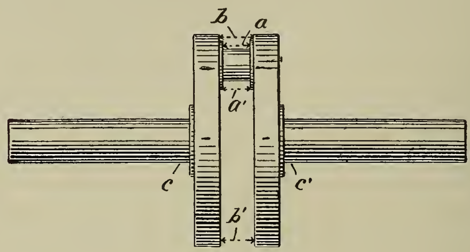


Fig. 182.

an extent which is seldom less than $\frac{8}{1000}''$, and when measured between the points a a′, the point a′ will always measure less than the point a by about $\frac{1}{100}''$. These differences vary somewhat with different sized cranks, but will be found to occur with remarkable regularity on the same sized cranks when they are put together under the same conditions, and therefore it is possible to devise and employ such means as will prevent the inaccuracy in both cases. The crank-shafts can be made to run perfectly true after the crank is shrunk together by setting the work so as to bore the crank-pin hole taper (with the axis of the crank-shaft) to a degree which shall correspond to one-half of the amount the crank-shaft runs out of true in the lathe. And in the same manner the difference in the distance between the points a a′ can be remedied by facing the ends of the crank-pin boss off more on one side than on the other, in the same proportion as above.

While the above differences are directly traceable to the fact that the work is always (in this case) unevenly heated, thereby causing it to expand more in one direction than another, it also proves very conclu-

sively that when a piece of work is shrunk in place it does not shrink back again (in cooling off) to its original shape, a fact which we have been able to verify repeatedly in our own practice. And hence, for the same reason, the excessive allowance usually given in the tabulated rules for making shrinkage fits are altogether uncalled for. An excellent rule for measuring the allowance to be made in making shrinkage fits was given in the "American Machinist" several years ago; this rule was to allow $\frac{1}{1000}''$ for every inch of the hole, and $\frac{2}{1000}''$ in addition. This rule is amply sufficient for all practical purposes, and agrees very closely with the comparisons we have made personally in many shops to obtain a rule applicable to this purpose. The only class of work with which we are acquainted, where the above rule cannot be consistently employed, is in boring the tires for locomotive engine wheels and for car wheels. The allowance in this case should be just double that given above, less the extra allowance of $\frac{2}{1000}''$. By the first rule the allowance for shrinkage for a 6″ hole would be $\frac{6}{1000}'' + \frac{2}{1000}'' = \frac{8}{1000}''$, and by the second rule, for a 60″ tire (internal diameter) the allowance for shrinkage would be $\frac{120}{1000}'' = \frac{12}{100}''$. The reason why such an excessive allowance is made for shrinkage for the tires of railroad engines and car wheels is that when only the ordinary allowance for shrinkage has been made the tires seem to work loose on the wheels after being in use for a short time, which, is in all probability caused by a process which is in effect analogous to "peening" produced by the action of the wheels in running over the rails, the effect of which at first appears to produce a circumferential expansion of the tire, and later, as the tire becomes worn, the metal seems to solidify somewhat, and the tire is re-contracted on the wheel center.

By employing the above rule for making allowance for shrinkage fits, a good mechanic will find very little difficulty in making the necessary measurements on the ordinary (machinist's) steel rule, or scale, as it is more commonly termed, as nearly every make of these rules or scales have one-fourth or one-half of an inch (or more) graduated to hundredths, and as in the first example given above, where the allowance for shrinkage for a 6″ hole is $\frac{8}{1000}$″, the allowance in this case would be a trifle less than $\frac{1}{100}$″; and by the second example the allowance happens in the case cited to be exactly $\frac{12}{100}$″, but when the diameter of the work exceeds 6″ it is usual to measure the allowance by even hundredths.

There are many ways of boring the holes in cranks for the crank-pin, which should, as already stated, always be done after the crank has been fitted and keyed on the shaft. Sometimes the hole is bored on the drill-press ("drilling machine") or on the boring mill (machine), and in other cases by means of a special boring appliance attached on the crank-shaft or disc. It is doubtful however if there are any means by which this operation can be performed as accurately, economically and expeditiously as on the lathe. There are two ways of doing it on the lathe. By the first method, the crank is held between the centers of the lathe, and the hole is bored by means of the boring attachment shown in Figure 124. By the second method the work is chucked on the lathe carriage, and the hole is bored by means of a boring bar, as shown in Figure 183, where A A represents the crank held on the V chuck B B, which is bolted to the lathe carriage (from which the tool-rest has been removed). The crank is shown in position for boring the hole C for the crank-pin by means of the boring bar D. In setting the crank, when it is desired to bore the hole slightly taper with the axis of the shaft

for the purpose explained, the crank end of the shaft is set as much closer to the boring bar as would equal one-half of what the crank runs out of true when

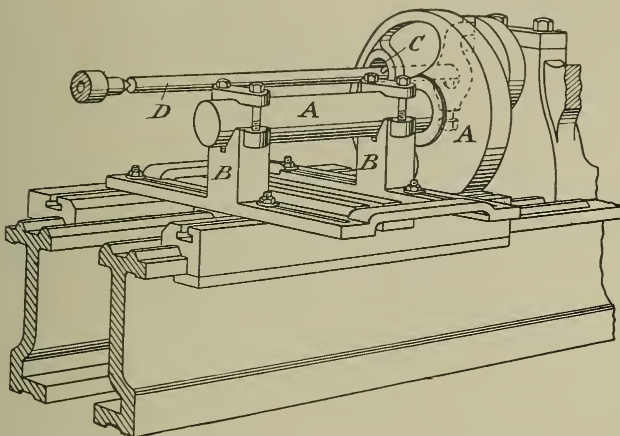


Fig. 183.

placed between the lathe centers after it is shrunk together, *as determined by observation on previous cranks of the same class.* Or, when the hole is to be bored with the work held between the lathe centers, the tail-center should be set over (out of line) to a like extent. But when the crank-pin is to be pressed in, then the axes of the shaft and boring bar should be set parallel with each other. When the crank-pin hole has been bored, the boss faced off, and the pin turned, the crank is ready to be shrunk together. The cranks are to be heated around the pin-hole, and then, while still hot, they are put together in the V guides, as shown in Figures 184 and 185, which represent a plan and end view of the crank and V guides.

In shrinking the cranks together, one crank, which

we will suppose to be the one shown at A in Figure 184, is first placed in position in the V guide B and held by means of the cap-plates a a′; the second crank A′ should now be placed in a similar position in the V guide B′, but the cap-plates b b′ should not as yet be tightened up; the crank-pin C is first inserted in the

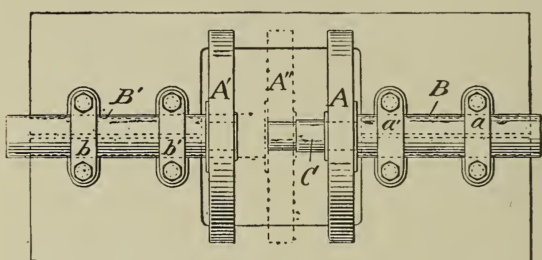


Fig. 184.

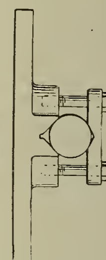


Fig. 185.

crank A and then in the crank A′ by pushing the latter up to the position shown by the dotted lines at A″. The cranks are then held and adjusted by means of the clamps D D′ D″, which are applied as shown in Figure 186, which represents a perspective view of the crank only, with the clamps in position thereon. As soon as the clamps have been applied and the cranks adjusted (set correctly), the cap-plates b b′ (Figure 184) should be tightened up and the crank left to cool off.

When the crank-discs are turned strictly on the interchangeable plan, the operation of adjusting (setting) the cranks can be greatly facilitated by interposing standard distance pieces, such as shown at E E′ (Figure 186), between the crank-discs.

The operation of shrinking the cranks together must be performed very quickly, in fact in much less time than it takes to describe it, otherwise the whole operation would result in failure.

The heating of the cranks is usually done on a special forge in such manner as to heat the metal immediately around the pin-hole without heating the metal around the shaft.

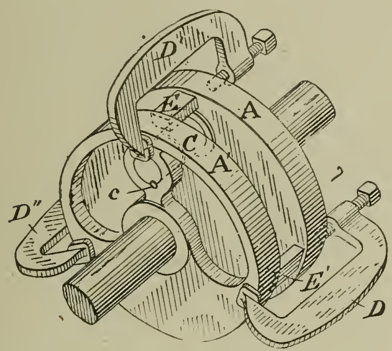


Fig. 186.

When the crank has cooled off, a retaining screw is inserted in each crank, drilling and tapping the hole for the same, directly on the division line of the pin and disc, as shown at c (Figure 186). The crank can then be put into the lathe, and when the alignment of the pin has been tested, the shafts and discs are trued up to size, supporting the weight, and steadying the work as much as possible in a steady-rest in the usual way.

To shrink in the pin of a single crank, it is only necessary to heat the crank as explained above, and then to insert the crank-pin in the hole as quickly as possible ; then if the crank-pin is out of line it should be riveted (peened) on the back side of the crank-disc in such a manner as to draw the pin over in the direction required.

In refitting crank-pins by the shrinking process in the driving wheels of locomotives, and also in the

cranks of other engines and machines, where it is desired to fit and shrink the pin in without removing the crank from its bearings, it is usual to heat the crank by putting red hot irons in the pin-hole until it has expanded as much as desired; the pin is then inserted as quickly as possible. The allowance for shrinkage in such cases is about the same as that made for a driving fit, the pin being afterwards riveted as an additional security.

In shrinking the parts of other kinds of work together, it is always, when possible, very desirable to have locating fixtures in which the parts can be held in correct alignment during the shrinking process.

A crank-pin that is worn or sprung out of true can frequently be trued up without removing it from the crank, thereby avoiding the expense and trouble of removing the old pin and inserting a new one in the place thereof. There is no doubt but what this would be done much oftener if a simple method for doing such work was more generally known. This job can be done very readily in any machine shop, either on the boring (machine) mill, or on the lathe, the crank-pin being set concentric with the axis of the live-spindle of the machine or lathe, and the tool revolved around the work in the manner shown in Figure 187, where the crank A is represented as being held in a pair of ordinary V chucking blocks B B′, which are mounted on the two blocks of wood C C stretched across and bolted to the lathe carriage. If a sliding tool-post such as D D is available, it should be bolted to the face-plate and the tool E adjusted to the cut, as shown in an obvious manner in the figure. But in case such a tool-post is not available, then the tool itself can be bent (offset) in such a manner as to admit of its being bolted directly to the face-plate. The tool is then adjusted to the cut by tapping it in or out as required with a hammer. The latter method is rather

a crude way to do a job of this, or any other kind, but it is much better than putting a new pin in, or trying

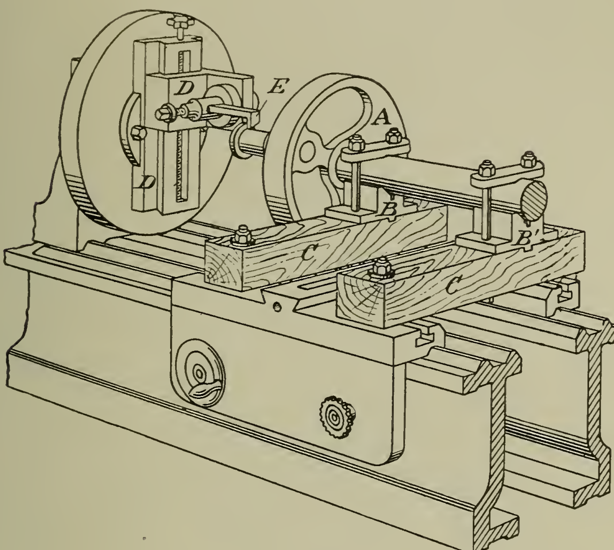


Fig. 187.

to true the old pin up by hand filing. The V chucking blocks should be correctly set as regards the distance and alignment before the crank is placed therein or the sliding tool-post is bolted on the faceplate, which can be done by placing an arbor or shaft of the same diameter as the crank-shaft in the V block, and a boring bar or similar shaft in the lathe centers, and then measuring or tramming from one shaft to the other.

An arrangement of this kind is also used for turning a variety of other work which is too large to be swung in the lathe.

CHAPTER XXV.

Lathe Work.—*Continued.*

BORING AND TURNING CYLINDERS.

There are a variety of ways for boring and turning cylinders of steam engines, pumps, ammonia and air compressors, and other machinery employing such cylinders for various purposes. The methods employed in general practice are always dependent on the facilities in the shop for handling such work.

Cylinders of small diameter are always bored and turned in the lathe everywhere. But in shops equipped with "modern machinery" the cylinders of large diameter are bored and turned on a special "cylinder boring and turning machine." In other shops, the cylinders are bored and turned on the "boring machine." But in most shops the cylinders of all diameters and sizes are bored and turned altogether on the lathe. In many places the facilities for chucking the cylinders are of the very crudest character, in fact the idea seems to prevail in such cases that anything is good enough for the purpose so long as it will hold the work in position for the operation, without paying any regard whatever as to whether the work is sprung or not by employing such methods. The above method usually consists in holding the work on wooden blocking roughly hewn out to approximate the shape of the cylinder body or

flanges and extending across the shears or carriage of the lathe, the work being bolted thereon, and the bolts strained to their utmost capacity. The facilities for turning the flanges and joints for the cylinder heads are always better than the boring facilities, as it is almost impossible to employ anything of a crude nature for this purpose.

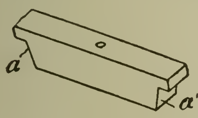


Fig. 188.

The simplest way to chuck the cylinder for turning is to insert the old-time centering bar, shown in Figure 188, in either or both ends of the cylinder in the manner shown in Figure 195, and then to chuck the work between the lathe centers in the ordinary way.

Another efficient method employed for holding the cylinders for turning is that shown in Figure 189,

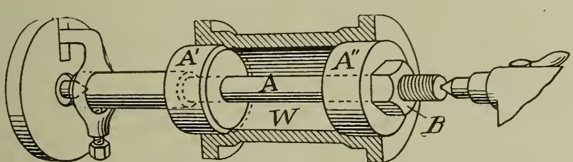


Fig. 189.

where the work (cylinder shown in section) W is held on the chucking arbor A, which consists of an arbor A, a fixed ring A′ and an adjustable ring A″, which are made to fit into the counter-bores of the cylinder; the work is tightened on the chucking rings by the jam nut B. The arbor A is used for different sizes of cylinders by having rings of different diameters to fit thereon.

In many cases the flanges and ends of the cylinders are turned before the cylinder is bored. The cylinder is then bolted to the face-plate, or held in an ordinary lathe chuck on the one end, and in a steady-rest on

the other end, and sometimes (when made in quantities) one end is held in a special chuck, such as shown in Figure 190, where A represents the chuck, broken

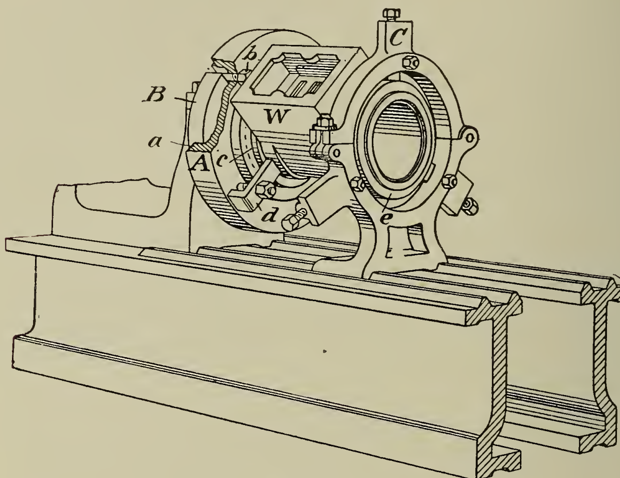


Fig. 190.

away at a to show the manner in which it is fitted onto the small face-plate B to which it is held by the bolts b (one only shown); the chuck is recessed at c to receive the flange of the cylinder W which is held in position by the clamps d; the outer end e of the cylinder is supported in the steady-rest C. The employment of the above chuck obviates the necessity of having to set the work, as it is self-centering. The cylinder is bored in the ordinary way by a tool held in the tool-post.

Another very efficient method of chucking, not only cylinders, but a variety of other work, is shown in Figure 191, where the work (cylinder) W is held in the hinged chucking rings A A′, which are bolted on the arms of the lathe carriage. The work is set by

means of the adjusting screws a a a and a′ a′ a′, is bored by the boring bar E in the usual manner, and afterwards turned on the chucking arbor shown in Figure 189.

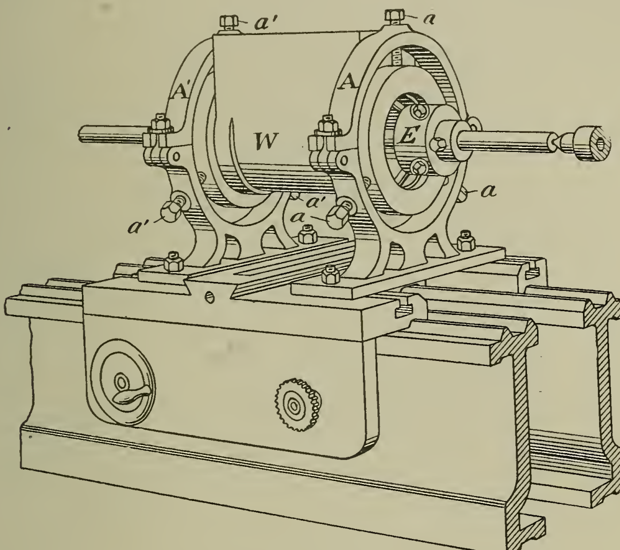


Fig. 191.

In most cases the chucking rings A A′ are made in one piece, but that form is not so handy as the above, as it is nearly always necessary, on removing one piece and inserting another piece of the work, to loosen all the adjusting screws, or else one of the brackets, to get the work out and in, thereby requiring as much time to set each piece of the work as it did for the first piece, which is not the case when the hinged form is used.

Another excellent device employed for the same purposes as those shown above consists of two V chucking

brackets A A, Figure 192, connected and adjusted as to length by two or three (as preferred) stay-rods B B′ B″.

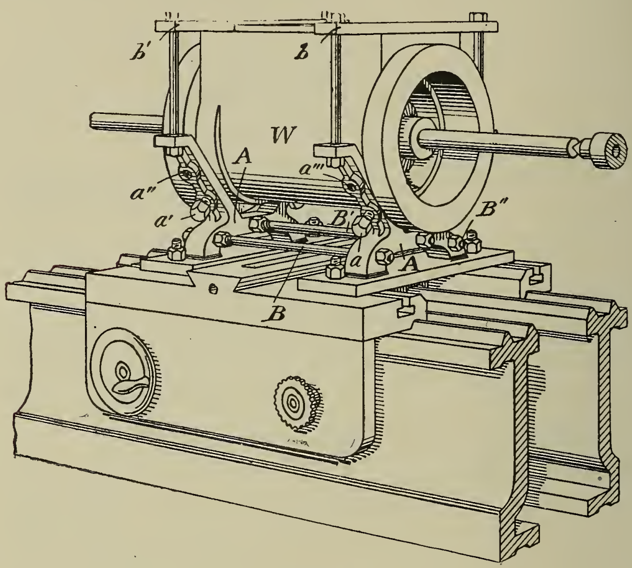


Fig. 192.

The V brackets are bolted on the arms of the lathe carriage. The work (cylinder) W is set by means of the adjusting screws a a′ and then held by the clamp-plates and bolts b b′. When larger cylinders are to be chucked, the adjusting screws a a′ are changed to the holes a″ a‴. In some respects this device is superior to any of the others, inasmuch as it admits of the work being chucked in such manner as to leave the ends of the work free to be operated on (turned) without having to re-chuck it. The boring is done with a boring bar, and the turning by means of a sliding tool-post, such as shown in Figure 72. The work is fed up to the cut by the regular carriage feed.

In some types of engines the cylinder, frame and guides are cast in one piece, one instance of which is shown in Figure 75, and another in Figure 95. It is very seldom that the cylinders and guides are bored elsewhere than on the lathe, even in shops equipped with "boring machines," as the work can be handled to better advantage on the lathe. When the size of the work will admit of it, the work is swung or revolved in the lathe, and the cutting done by fixed tools in the same manner as on other work. But when the work is too large to be swung in the lathe, then it is chucked partly on the lathe carriage and partly on an auxiliary rest or carriage and the cutting done by revolving cutters in the ordinary way.

Figure 193 shows the manner in which the work is chucked and driven when revolved in the lathe. In the figure the work represents the vertical engine frame shown in Figure 75. Before the work is chucked for boring, it is first centered and then chucked between the lathe centers to face off (true up) the base, a centering bar X shown in Figure 194 (which represents a perspective view of the base only chucked on the lathe center O) being cast in the base for this purpose, and afterwards broken off. The cylinder end is chucked in a similar manner by means of the centering bar a (shown in Figure 188), as shown in Figure 195 (which represents the cylinder only chucked on the center o′). When the base has been faced off the flange V is trued up to furnish a bearing for the work in the steady-rest. As shown in Figure 193, the work is supported on the one end by bolting the base to the face-plate, and on the other end in the steady-rest. The boring bar A A is supported and held on one end in the tail-spindle E, and on the other end in a guide bracket B, which is held on the face-plate. In order to take up the lost motion, and to prevent the continual jarring and jumping of the work as the cutting

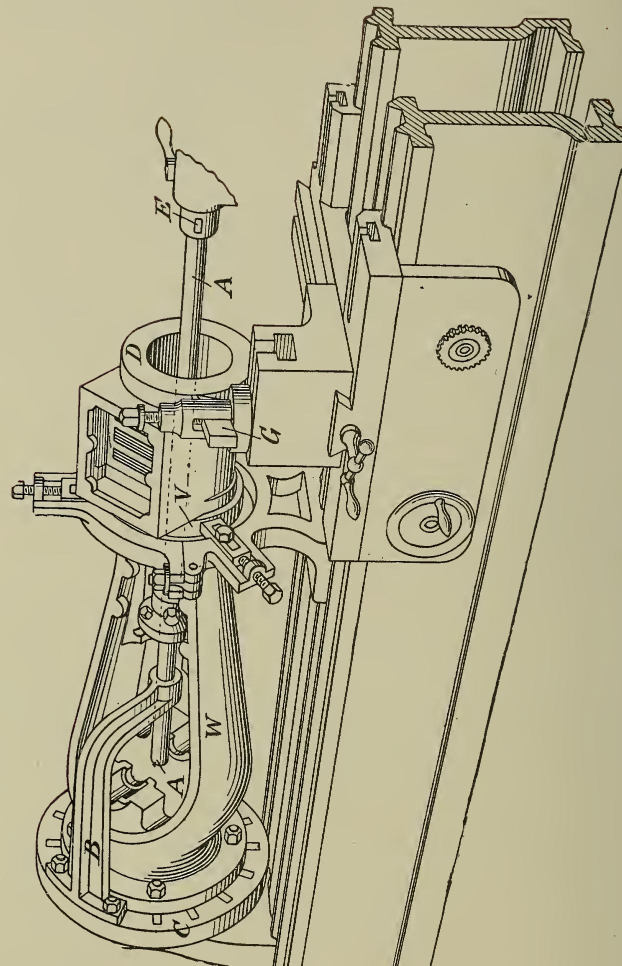


Fig. 193.

tools come in contact with and are released from the guides, it is usual to turn the flange D simultaneously with the boring of the guides, using a very fine feed to prolong the turning operation as much as possible, the turning tool G, which is shown in position for the operation, being fed by means of the regular carriage feed. When the opening in the base of the frame will admit of it, the guide bracket B is located on the inside of the frame, and is made with two arms instead of one. But when employed as shown, the position of the work should be reversed to bring the

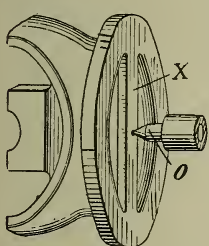


Fig. 194.

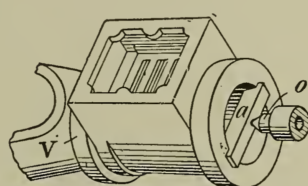


Fig. 195.

steam-chest on the opposite side to the bracket, in order that the weight of one will counter-balance the weight of the other.

In all operations of this kind, the importance and necessity of having an automatic feed on the tail-spindle will readily be seen, as it is necessary for the operator to give his whole attention to the cutters and work, without having to become a part of the machine itself (as it were), by performing a part of the work which can always be done more efficiently and expeditiously by the machine.

When the work is too large to be swung in the lathe, as in boring and turning the cylinder and guides of the vertical engine frame shown in Figure 95, the work is chucked on the lathe in such manner

as will admit of its being operated on to the best advantage with the facilities provided for that purpose. If the lathe is provided with a boring bar having a sliding (traversing) cutter-head thereon, the work can be chucked stationary either on the lathe shears or carriage, or both; but when the lathe is only provided with an ordinary boring bar, the work must be chucked in such manner as will admit of its being fed up to the cutters, as the cutters cannot be fed through the work.

Figure 196 shows the manner in which the vertical engine frame (mentioned above) is chucked on the lathe for boring the cylinder and guides and the temporary guide bar C. In the figure, W represents the work, held by the lower flange f of the cylinder in the chucking ring B, and by the feet of the standards on the auxiliary chucking-rest F F′, which is connected with the lathe carriage by the reach-rods D D. The work is set on the cylinder end in the ring B in the ordinary way, and on the foot end on the auxiliary slide F F′ by means of the adjusting screws b b b b, and is held thereon by the bolts and strap a. The hole in the guide bar C is bored first by means of a smaller boring bar.

The frame is broken away to show the interior.

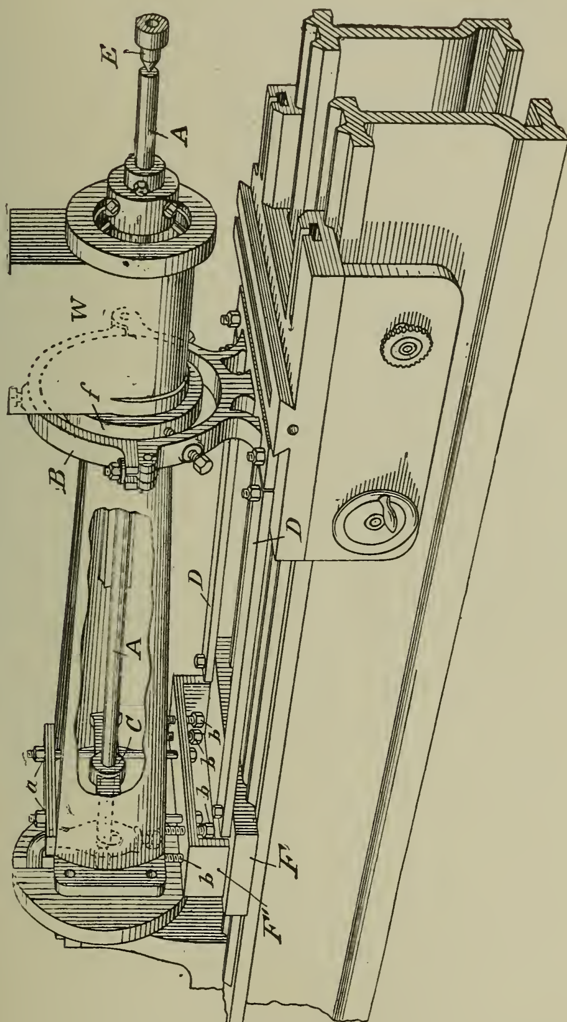


Fig. 196.

CHAPTER XXVI.

Lathe Work.—*Continued.*

TURNING AND BORING TAPERS.

The accuracy with which taper work can be turned and bored depends almost entirely on the facilities for doing such work. If the facilities are incomplete the job may be very difficult of accomplishment, but with the proper facilities, taper work can be turned and bored with the same facility as parallel work. On the American built lathes there are three methods by which taper turning can be accomplished and two methods of boring taper holes. The first and almost universal method employed for taper turning is by setting the tail-stock of the lathe over in such manner as to throw the tail-center out of line with the live-center, so that, though the turning tool is traversed parallel with the lathe-shears and live-spindle, the work is turned to the taper required.

The second method is by employing a taper-turning former attachment (known as the "Sellers taper-turning attachment"). This is the favorite and really the most practical of any.

The third method is by using a compound (auxiliary) slide rest.

For boring taper work the second and third methods (given above for taper turning) are the only ones employed in general practice.

In England and other European countries the head-stock of the lathes are adjustable on the lathe bed as well as the tail-stock, a very desirable feature (not possessed by the American built lathes), which

admits of the head-stock being set over (out of line with the lathe-shears) whenever it is desired to bore taper holes. This method is employed almost to the exclusion of any other method when boring taper work in England. Another method which is also used to some extent for the same purpose is by means of the auxiliary slide rest, as already explained, the Sellers taper-turning attachment being very little used in the European countries.

For turning tapers the methods employed in the above countries are, first, by setting the head and tail stock of the lathe in line with each other, but out of line with the lathe-shears to the angle required; secondly, by setting either the head-stock or tail-stock over to the angle required in a similar manner, and thirdly, by means of the auxiliary slide rest. On short tapers this latter method is preferred to any other.

In all cases when the lathe is provided with a taper turning and boring attachment, the tapers are turned and bored altogether by that means.

Many lathes are provided with both the latter facilities, and when so arranged, the tapers are turned and bored by means of the taper-turning attachment, and the tool is adjusted by means of the auxiliary slide rest.

By the ordinary rules the calculations for setting the lathe to turn taper are made as follows: When the work is to be turned taper the whole of its length, the tail-stock, auxiliary slide rest or taper-turning attachment are set out of line with the lathe-shears to an amount which equals one-half of the taper to be given the work. And in like manner when boring taper holes, the head-stock (when it is adjustable), auxiliary slide rest or taper-turning attachment are set out of line to the same extent but in the opposite direction.

When the work is to be tapered a part of its length

only, it is usual to calculate the ratio of the taper per foot for the whole length of the work. As for example, in turning the taper-shank a of the piston rod A, Figure 197, we must first reduce the length

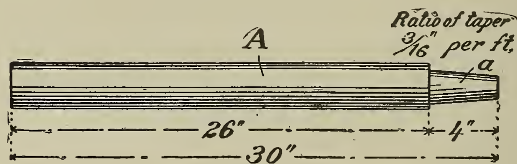


Fig. 197.

of the rod to inches, then divide that by the number of inches to be tapered, and multiply the quotient by the amount the work is to be tapered.

In this case the length of the work is 30″ over all; the part to be tapered is 4″ long, and the amount of taper $\frac{1}{16}''$ in 4″ = $\frac{3}{16}''$ per foot, or $\frac{1}{64}''$ per inch, which for the whole length of the work would equal $\frac{30}{64}''$, and one-half of this, or $\frac{15}{64}''$, equals the amount the tail-stock or other taper-turning appliances should be set over to turn the taper required.

To be strictly correct, the distance which the lathe centers enter each end of the work should be deducted from its length in computing the amount to which the tail-stock should be set over, but this does not effect the calculation when the taper-turning attachment or auxiliary slide rest are employed for this purpose. And in fact it is very seldom that any such allowance for the same is made, even when the tail-stock is used.

The most accurate and expeditious method of setting the lathe for boring or turning tapers is by means of a "bevel-gauge" (usually termed in the workshop "bevel square"), which is applied as shown in Figures 198 to 201.

The amount of taper being known, the bevel-gauge can be set to the correct angle for the taper required, by the method shown in Figure 198, which consists

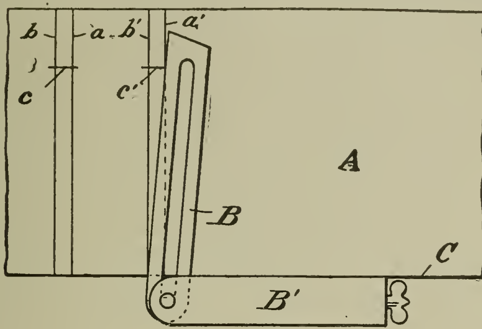


Fig. 198.

in making two perpendicular lines a b at right angles to the parallel edge C of the plate A, said lines to be one-half the distance apart of the taper to be given the work. The length of the taper is then laid off on the line a, as shown at c, and the bevel-gauge B B′ is set to the correct angle in the manner shown at a′ b′ c′.

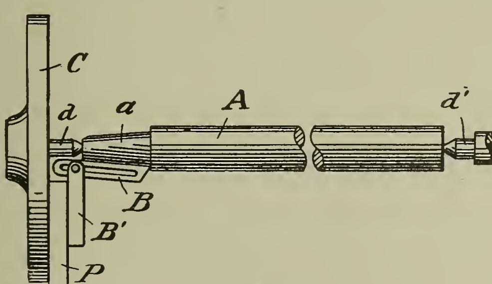


Fig. 199.

Or, when the job consists in making a new piston rod to replace the old one, the operation can be still further simplified by placing the old-rod A in the

lathe centers d d′, with the taper end a of the rod on the live-center d, as shown in Figure 199, and then adjusting the gauge B B′ in the manner shown therein, placing a parallel P between the face-plate C and the stock B′ of the bevel-gauge, to admit of the gauge being set to the angle required without coming in contact with the center. The new-rod A is then placed in the centers d d′, and the center d′ (tail-stock) is set over until the rod stands at the angle desired, as shown in Figure 200. The rod is then in the right

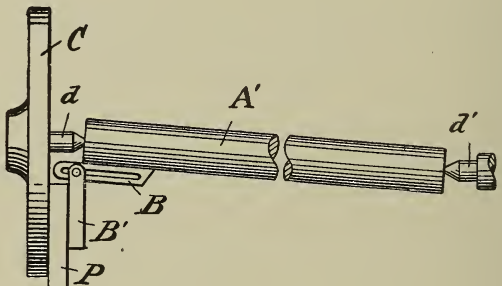


Fig. 200.

position for turning the correct taper on the dead-center end d′ in the usual manner. Or, if the taper is to be turned by means of the auxiliary slide rest, the auxiliary slide rest is set to the angle required in precisely the same way, as shown in Figure 201, where, after the bevel-gauge has been set to the right taper by either of the above methods, the stock B′ of the gauge is held against the face-plate C or parallel P, and the rest D is set to the same angle as the gauge.

In setting the work by the method shown in Figure 200, the length of the work, or the distance the lathe centers enter into the same, has nothing whatever to

do with the accuracy with which the work can be set, and there is no doubt but what it is the most correct of any method known for setting the head-stock and tail-stock or compound slide rest for turning or boring tapers.

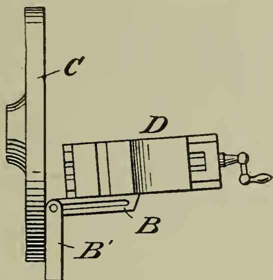


Fig. 201.

When the Sellers taper-turning attachment is employed, it can be set to turn or bore any taper required very readily, as it is graduated for that purpose.

Other methods of turning and boring tapers which are known to the author are not given, because they are not employed to any extent in general practice.

A very simple taper turning and boring attachment, which can be made and applied to any lathe, is shown in Figure 202. This device consists of a parallel former guide bar A, slotted in the center of its length to receive the roller D on the end of the arm C, which extends from the tool-rest E. The guide bar A is mounted on the brackets B B′, which are fixed on the head-stock and tail-stock respectively, as shown, and which are each provided with a slot by means of which the guide bar can be adjusted to the angle required. When turning taper work, the guide bar is pivoted on the bracket B, and is adjusted to the angle required on the bracket B′. But when boring taper holes, the guide bar is pivoted on the bracket B′, and adjusted on the bracket B (which is shown broken away).

The foregoing device is particularly adapted to lathes which have no adjustment of the head or tail stock, and are not provided with a compound slide rest.

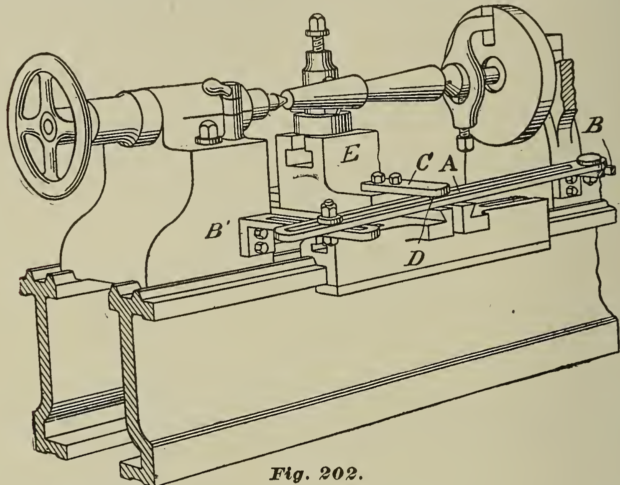


Fig. 202.

As the feed-screw of the cross-slide is always disconnected when a taper or former turning attachment is being used on lathes of this description, some means must be provided for adjusting the tool to the cut, or the adjustment must be made with a hammer. Figure 203 shows the method adopted by the author for making the necessary adjustment of the tool to the cut in cases of this kind. As shown therein, the device consists in making the base ring A of the tool-post T with an extension on the front, in the form of a lug B, which is threaded to receive the adjusting screw C, and the tool is adjusted in an obvious manner thereby.

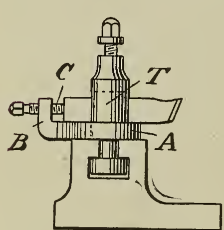


Fig. 203.

This device is practically equivalent to a compound slide rest so far as its application to the adjustment of the tool to the cut is concerned, and its use admits of the ordinary lathe being employed for former turning with the same facility as the compound lathe.

CHAPTER XXVII.

Lathe Work.—*Continued.*

EXAMPLES OF FORMER TURNING, ETC.

The necessity of turning irregular forms of work seldom occurs in general practice, as irregular forms are always (whenever possible) studiously avoided in the designing of all kinds of modern machinery, but when such forms are employed at all, it is usually for cams and cam-motions, and the work is machined on a special cam-cutting or milling machine, or it is done on a "former-lathe."

* "The method by which former turning is usually accomplished on the ordinary lathe is by means of an arrangement in which a former of the desired shape is operated on a spindle attached to the back of the lathe, and which is made to revolve in unison with the live-spindle and work by gearing from the live-spindle to the former-spindle. A tracer-arm or pointer is extended from the tool-rest to the cam, and is kept in constant contact with the cam by means of a weight, the device being operated in such a manner as to cause the turning or boring tool to advance to or recede from the work as the former and work are revolved, thereby turning the surface of the work the same shape as the former cam."

While a knowledge of the methods employed in former turning may not be absolutely necessary to the lathe-hand or machinist in general practice, still, as it does occasionally happen that irregular forms are, for specific reasons, employed in machine construction,

* "Modern Machine-Shop Practice," Vol. I., Chap. XIII., p. 326.

a knowledge of such processes is very essential when such instances do occur.

In a certain engine works in England it was decided to employ a valve-rod slide for operating the valves—of elliptic or oval section. Instead of using the revolving former and tracer-arm (mentioned above) for turning these slides, the method employed for actuating the cross-slide rest and tool was that shown in Figure 204. As shown therein, the method and

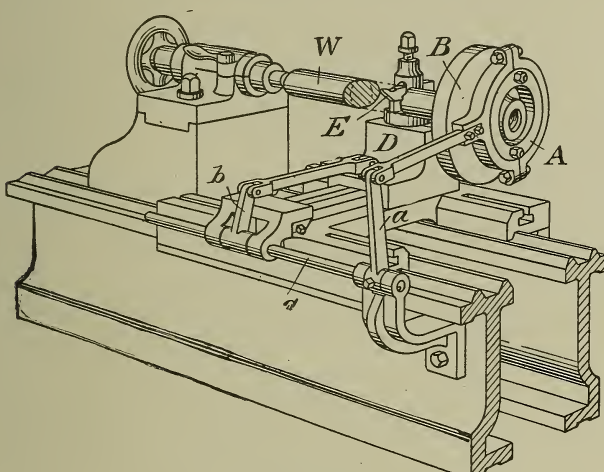


Fig. 204.

device consist in employing an eccentric A on the back of the face-plate B to actuate the rock-shaft C in such manner as to impart a reciprocating motion to the cross-slide (tool-rest) D, causing the tool E to advance to and recede from the work W (which is broken away to show the form and method to better advantage).

The difference between the greater and lesser diameters of the ellipse is regulated, first, by varying

the throw of the eccentric A, and secondly, by varying the length of the rocker-arms a and b. In this case the rocker-arm a is twice as long as the arm b, and consequently the throw of the eccentric A is just twice as much as would be required to produce an ellipse of the diameters shown in the engraving, if the rocker-arms a and b were of equal length.

While the difference in the two diameters of the ellipse is regulated by varying the throw of the eccentric and the length of the rocker-arms, the work is turned to size, by adjusting the tool to the cut in the ordinary way.

The boxes (bearings) for the slides are bored elliptic to fit the slide by means of the same device, chucking and boring the work in the same manner as in boring circular holes.

Excellent work can be done by means of this device, but there is one peculiar feature about turning and boring with it which it is well to mention to avoid inaccuracies. This peculiarity refers to a slight indented ridge formed on the work (the whole of its length) exactly at the point where the tool E is shown in contact in the engraving; this occurs whenever the tool comes to rest, as the eccentric is passing the "dead-centers" at the two extremes of its throw.

The occurrence of these ridges on the work is not confined to this particular kind of former-turning attachment, but pertains in like manner to all kinds of former-turning appliances where the tool and all the parts come to rest at certain points of the revolution of the work and former. The ridges thus formed are almost imperceptible on the work, but at the same time are sufficiently large to interfere with the accuracy of the fits, and have to be removed from the slide by "draw-filing," and from the boxes by "scraping."

The next example of turning formed work shows

the method employed for turning what is termed a "cam-shaft." It is turned out of square "stock," and is employed for operating a series of rams on a riveting machine, instead of using a separate cam for each ram.

As shown in Figure 205, the device is in part the

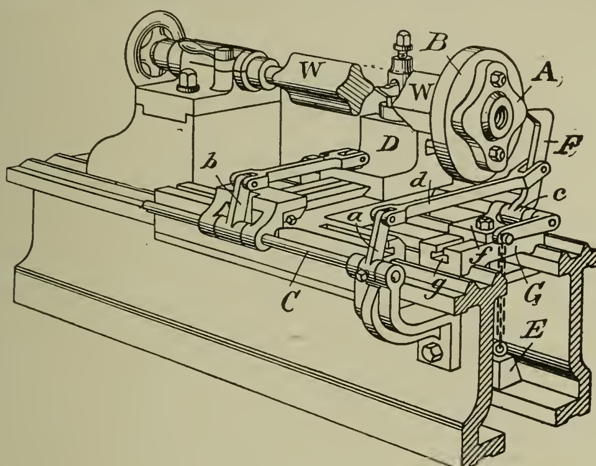


Fig. 205.

same as that shown in Figure 204, but the means employed for operating the rock-shaft C and its appurtenances are modified to make it applicable to the work. In this case the rock-shaft, etc., are actuated from a tracer-arm F, which is pivoted at c in the saddle-block G, and is connected with the rocker-arm a by means of the connecting-rod d. The tracer F is held in constant contact with the former A (which is fixed on the back of the face-plate B, concentric with the axis of the same) by means of the weight E. Provision is made for adjusting the tracer-arm F vertically, by making the pivot-block f adjustable in the T slot g of the saddle-block G. This adjustment

is necessary when formers of different sizes or formers for other classes of work are employed.

The accuracy of the work turned by this method will depend in a great measure on the accuracy with which the parts of the device are fitted together, and care must be observed to see that there is no lost motion in any of the joints and connections.

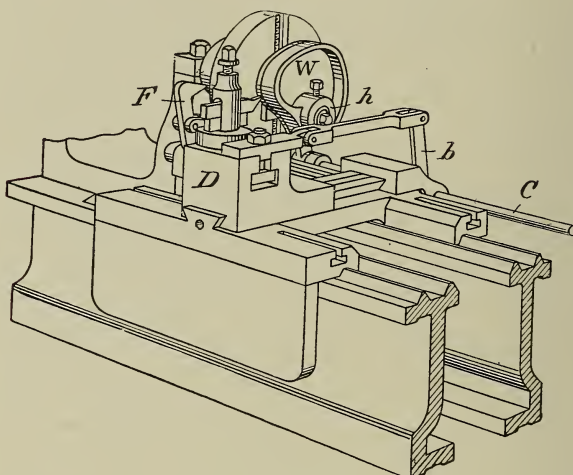


Fig. 206.

The object in arranging the former turning device in this manner is, first, to avoid the inconvenience occasioned by fixing the operating mechanism on the front part of the lathe, and secondly, to arrange the whole mechanism in such a manner as not to interfere with the ordinary functions of the lathe further than having to disengage the feed screw of the cross-slide, and thirdly, that irregular work of any diameter and almost any shape can be turned by means of the same device.

The former should be made of good hard cast iron or of sheet steel, and should be of such width as will

furnish ample bearing for the tracer. To turn formed work of small diameter it will be necessary to make the former on an enlarged scale, and to reduce the motion of the cross-slide rest and tool by varying the length of the rocker-arms in proportion. But when turning cams and similar work, when the diameter will admit of it, the former should be made of the same size and shape as the work to be turned.

Figure 206 shows how cams are chucked and turned by means of the same device. In setting the former and work for turning the outer surface of the work, it is arranged to conform its greatest diameter within the limits of a true circle, and both the work and former are set within the limits of this the given circle, concentric with the axis of the live-spindle, in precisely the same manner as an eccentric would be chucked for turning. This will be better understood by referring to Figure 207, which represents a front view of the cam W held on the chucking arbor in position for the operation, the former being fixed in the same relative position, but on the back side of the chuck, the dotted lines representing the circle within the bounds of which the work and former are set, O representing the common axis of the cam (and also that of the live-spindle); the hub h is bored eccentric to the same for apparent reasons.

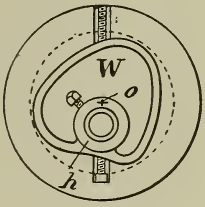


Fig. 207.

In setting work for boring by the same process, the internal surface is arranged and set in precisely the same manner as for turning, and the boring is done in the same way as though boring circular holes.

As the diameter of the cam (work), shown in Figures 206 and 207, admits of the employment of a former of the same size as the cam itself, the rocker-

arms are made of equal length, and the connection from the arm b to the cross-slide rest is made more direct with the tool.

This method admits of cams and other irregular shaped work being turned with the same facility as eccentrics are turned, the only difference being that the turning tool must be relieved (backed off) on the under side to clear the work at every part of its circumference during the operation.

In place of having a fixed point on the tracer-arm F (Figure 205), a small roller can be employed if desired, but as the roller wears very rapidly, and affects the accuracy of the work to some extent, a solid pointer is to be preferred for this purpose.

These examples of turning irregular shaped work do not represent anything of an extraordinary nature, but are introduced herein to show how the ordinary facilities have been and may be improved upon to do work which would otherwise have to be done on a special forming lathe or machine.

CHAPTER XXVIII.

Lathe Work.—*Continued.*

BORING AND TURNING BUSHINGS, HOLLOW SPINDLE-LATHES, GANG LATHES.

The question as to how bushings are chucked when made in quantities for boring and turning is frequently asked in the trade journals, and as the methods proposed in answer to the queries do not seem to accord with those employed in modern practice for doing such work in some of the large agricultural works, where such bushings are made and used in larger quantities than elsewhere, it is thought advisable to show them here.

These bushings are used very extensively in the construction of agricultural machinery and are usually made of composition or brass. Two forms are used, namely, split and solid bushings, and either or both forms are made straight or tapering on their outer diameter to suit the requirements in the construction of the machine. The split bushings are usually the most difficult to handle, but with the proper facilities and manipulation the difference is scarcely preceptible in operating on either form.

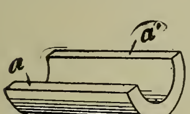


Fig. 208.

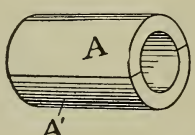


Fig. 209.

When the bushings are of the split form, as shown in Figure 208, the joint surfaces a a′ are first ground or milled parallel. The two halves A A′ are then placed together, as shown in Figure 209. The next

operation consists in facing off the ends and making the bushing of the length desired. This is done by clamping the two halves A A′ of the bushing on the mandrel B (the upper half A of the bushing being broken away to show the form of the mandrel), as shown in Figure 210, holding them firmly in position for the operation by means of the screw-clamp C. As shown in the figure, the mandrel B is made to be run between the centers, but when preferred, it is arranged in the form of an arbor-chuck and is fixed on the nose of the live-spindle, or in the socket for the live-center. The bushings can now be either bored or turned as preferred, the manner of chucking being the same whether either operation has been first performed or not. To turn the outer diameter the bushings are chucked, as shown in Figure 211, on a special chucking arbor B, the work A A′ being held tightly against the shoulder a by the nut C; the collar B′ of the arbor B and the nut C (at b) are reduced in diameter to avoid any interference with the operation of the turning tool.

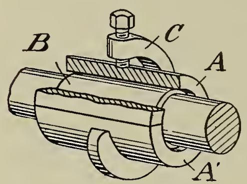


Fig. 210.

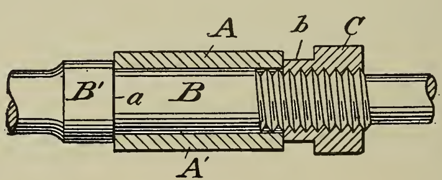


Fig. 211.

When the bushings have been turned to size, they are held for boring in a chuck such as shown in Figure 212 (the chuck C C′ and work A A′ being shown partly in section). The chuck C consists of a

hollow sleeve, bored and threaded at a to fit on the nose of the live-spindle B; it is also threaded on the outside at b for the jam-nut C′. The chuck is chambered out at c to provide clearance for the boring tools as they pass through the work.

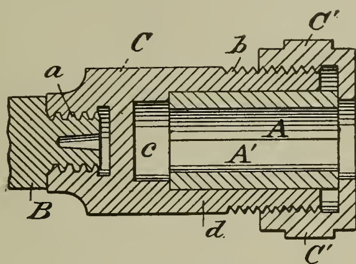


Fig. 212.

Another form of chuck employed for holding the work while it is being bored and faced on the ends is shown in Figure 213. This chuck is of the well-known collapsing form, and is similar in construction to that shown in Figure 212, except that it is tapered at b, and the sleeve d has three radial slits e e e, which admit of the jaws being closed as the binding nut C′ is tightened up.

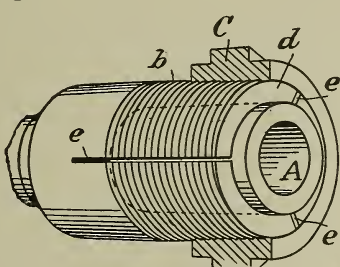


Fig. 213.

This latter form of chuck is employed more for holding solid bushings than for those that are split,

principally with a view to providing a means for facing off the ends at the same time that they are bored.

In other cases this is accomplished by holding the work on an expanding mandrel, by which means the bushings can be faced off on the ends and turned on the outside at the same chucking. An arrangement of this kind is almost a necessity when the bushings are of the tapered form, as it would be rather difficult to face off the ends by other methods. This form of chuck is shown in Figure 214, A A′ representing the

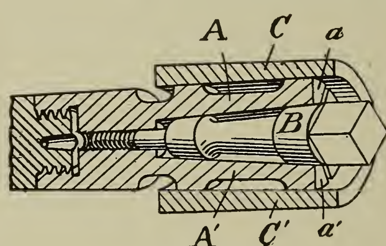


Fig. 214.

chuck, B a taper plug, by means of which the jaws a a′ are expanded to hold the work (taper bushing) C C′.

The construction of all these chucks can be modified considerably on a lathe provided with a hollow live-spindle, as the chucks can be arranged to handle the work more rapidly, and the different processes facilitated throughout.

LATHES WITH HOLLOW LIVE-SPINDLES.

Every machine shop should be provided with at least one lathe having a hollow live-spindle, for it can be utilized for such a variety of purposes that its value can scarcely be overestimated. In fact, if but one-half of the purposes to which it can be applied were

better understood, there is not the least doubt but what a large percentage of the solid spindle-lathes would be supplanted by the hollow spindle-lathe, but unfortunately the advantages of such lathes are so little understood in many shops that the hollow spindle is actually regarded as an undesirable and unnecessary feature. And in other cases the merits of such lathes are so poorly appreciated that little or no use is made of their capabilities. And then again, on the other hand, in many shops every possible use is made of the advantages such a lathe offers, and it is here, and here only, that we can see the possibilities and best examples of what can be accomplished on such a lathe over the ordinary solid spindle-lathe. And here again we get an insight as to what constitutes "Modern Machine-Shop Practice."

GANG LATHES.—SETTING TWO LATHES SO AS TO HANDLE EXTRA LONG WORK THEREIN.

Every machine shop, large or small, making specialties, or doing a general business, should provide a means for handling extra long work, as such a contingency is sure to occur at some time or other. Usually such a contingency is provided for by having at least one lathe in the shop with a bed from twenty to thirty feet in length, but under ordinary circumstances such a lathe is an incumbrance in the shop, as it can only be used on short work the greater part of the time, unless an arrangement is made by which a "gang" (series) of lathe-heads can be set and operated on the same bed, and employed exclusively for doing chucked work, or for turning short work. To arrange the lathe for this class of work, it should be fitted with as many head-stocks and carriages (in series) as can be conveniently operated on the lathe bed. On ordinary work, when employed for chucking purposes

only, a head-stock and carriage should not occupy a space of more than five feet, and as each carriage is provided with a separate feed-rod and gearing for operating the same, a thirty-foot bed would contain a gang of six independent head-stocks and carriages, thus making it equivalent to six lathes. The author has seen a lathe with a bed fifty feet in length arranged in this manner for doing chucked work, with nine head-stocks and one tail-stock and nine carriages, every other head-stock in the series being left-handed, so that the two face-plates face each other, making it possible and convenient for one operator to run two lathes, the last lathe in the series being employed for turning. Occasionally this lathe was employed for turning extra long work, such as facing and turning long cast-iron columns, and at times thirty or forty foot lengths of shafting. The intermediate head-stocks were then removed, but all the carriages were operated simultaneously by means of one common feed-rod.

Independently of the lathe being applicable to the purpose of boring and turning work of extra length, it was the greatest economizer of space we have ever seen as far as its adaptation and employment for gang lathes is concerned. We have frequently seen two head-stocks and two tail-stocks operated on the same lathe bed, and it would seem as though there must be some gain in the employment of this method, or it would not be employed by intelligent and wide-awake managers and manufacturers, and therefore it seems as though the same plan could be used to advantage in many other cases.

Another plan for handling work of extra length that is frequently resorted to is to set two lathes end to end in such manner that their centers will be coincident with each other. Then by removing the head-stock of one lathe and the tail-stock of the

other the work can be placed between the centers as though it were one lathe. The carriage of the lathe from which the head-stock has been removed is fed along the cut by connecting it with the carriage of the other lathe by means of a chain, or, if preferred, the work can be changed end for end, and operated on in that manner.

In setting the centers of two lathes in line with each other, as explained above, the lathes need not necessarily be of the same size.

In modern practice the capacity of boring and other machines is frequently increased by setting the machines in such positions that when the work is too large to be handled to advantage on one machine the second machine is brought into requisition, admitting of work being operated on which would otherwise require a larger machine, or have to be done by other and more expensive processes.

CHAPTER XXIX.

Lathe Work.—*Continued.*

CIRCULAR CUTTERS.

The employment of circular cutters for turning purposes is always confined in general practice to turning what is termed "formed work," and when so employed the tool is advanced to the cut from the outer diameter of the work towards its center or axis, thereby turning (forming) the work to the exact shape of the cutter, except in those cases where a circular cutter is employed for turning small fillets and rounding the corners off on work, or is used as a cutting-off tool.

In the first case, when circular cutters are employed for turning "formed work" in the lathe, the cutter is termed a "shape tool," but in the other cases they are simply termed "cutting-off" tools, "fillet" tools, etc., the same as any other tool employed for the same purpose.

Circular cutters have been employed for the above purposes for many years, but the application of such cutters to the purpose of taking traversing cuts on work in the lathe is (as far as we have been able to ascertain) of very recent date, but the success which has followed their employment has been very gratifying and satisfactory.

For ordinary turning purposes two kinds of these cutters can be used, namely: those that are turned circular, and those that are "backed-off" or relieved in the same manner as milling cutters are relieved. When the relieved form of cutter is employed, it is held on a plain vertical tool-holder; but when the

unrelieved form of cutter is employed, it is held on an inclined tool-holder, the inclination of which corresponds to the amount of clearance required to be given the cutter. In either case the cutting points of the tools are made to correspond in shape to the ordinary turning tools employed for the same purpose. When the cutters are of large diameter they can be cut out to form either three or four teeth or cutting edges as desired, but when the cutters are of small diameter three divisions or teeth are usually sufficient.

The principles governing the construction and operation of circular cutters are precisely the same as those which are applied to all other forms of turning tools, as far as the shape of the cutting edges, clearance angles and the position in which the tool has to be set is concerned.

Figure 215 represents a circular turning tool of the unrelieved form. The circular cutter A is held on the inclined tool-holder B by means of the binding screw C. In this case the cutter has three divisions or teeth, and is inclined in an obvious manner, to give the necessary clearance to the cutting edge. If the cutter was held by the binding screw (or pivot) C alone, it would be necessary to serrate or notch the cutter on the side next to the tool-holder B, to prevent the cutter from turning on its pivot when applied to the cut; but as shown therein, the tendency of the cutter to turn on its pivot is avoided by placing an adjusting screw D on the under side of the tool-holder in such manner as to take the greater part of the strain off the pivot pin, and also to provide a means for retaining and adjusting the cutting edge of the tool to the height

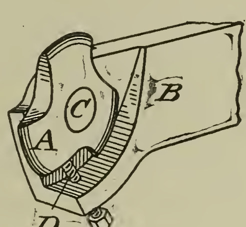


Fig. 215.

required. The advantages of circular tools consist in there being three or more cutting points, any one of which may be used as desired, and in the same clearance angles being retained as long as the cutter is used, regardless of how much it may be ground, as the grinding is only done on the top surfaces of the cutting edges. When it is desired to change from one cutting edge of the tool to another, the adjusting screw D is simply backed out of the way and the cutter is rotated until the point desired is in position.

Circular tools having a single cutting point have been employed for many years for thread cutting (turning), but as their employment does not appear to have been any more (if as) satisfactory than the ordinary single point solid threading tool, they have not been very extensively adopted. This appears to be due to the fact that the clearance angles of a true circular cutter are too obtuse for thread cutting, as they cause too much abrasion on the sides of the thread they are cutting, and hence an excessive wear on the cutting edges. But when the cutting edges are backed off or relieved for the clearance angles in the manner that milling cutters are relieved, then this abrasion does not occur, as the clearance angles can be made as acute as desired, the principles being precisely the same as those observed in making taps and dies.

Circular cutters backed-off (relieved) in the above manner are superior to any other form either for thread cutting or for ordinary turning purposes.

A single point circular threading tool may be made in the form of a disc with the edges converging (at the angles desired) to a point. Or it may be made in the form of a disc with a single thread cut on its periphery. If made in the latter form the thread should be cut left-handed for cutting a right-handed thread, and *vice versa* for cutting a left-handed thread.

Or if the cutter is turned right-handed, and is to be used for cutting a right-handed thread, it will have to be inclined and the upper surface of the cutting edge ground off to give the necessary clearance angles. This will be better understood by referring to the circular threading tool shown in Figure 216, which was made and used by Mr. A. Crocker. In this case the cutter A was made from the body of a tap, the threads being inclined, and the upper surface a ground off for clearance. This makes a very efficient threading tool, is said to give superior results and to last for an almost indefinite period. If the body of a left-handed tap is employed in the same manner, it does not have to be inclined, or have the upper surface of the threads ground off for clearance, as this is already provided for if the tap has been made by the regulation methods, as already explained. The action of a threading tool of this kind is similar to that of a chaser, which, it is claimed, produces a more perfect thread than can be made with a single point (solid) tool.

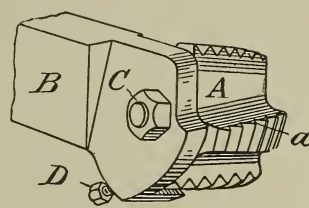


Fig. 216.

Chaser-tools are frequently employed for threading taps and other work for the above reasons, but personally, from our own experience in this respect, we are inclined to favor the finishing of all threaded work that requires to be made to exact standard sizes by means of a "sizer-tap" or "die," after the work has been threaded in the ordinary way.

BOX-TOOLS, WITH PLAIN AND CIRCULAR CUTTERS.

When box-tools are used on the ordinary lathe they

are always held and centered in the tail-spindle. This is an excellent means of using such an appliance, but the benefit to be derived from its use is frequently curtailed by making the shank taper, to fit into the socket of the tail-spindle instead of making a hub and fitting it on the outside of the spindle, thereby making it more rigid and much more capable of fulfilling the purpose for which it is intended.

A box-tool fitted in this manner will usually give very satisfactory results, if properly constructed; and in case the work requires some subsequent operation to be performed thereon, before it is cut from the bar, it leaves the lathe carriage and tool-rest at liberty for this purpose. It not infrequently happens though that the box-tool may be arranged in such a manner that all the operations can be performed either simultaneously or in succession by the box-tool itself. It is hardly to be expected though that if the box-tool is held on the tail-spindle the best obtainable results can be secured, for the support offered by the tail-spindle is not sufficient for handling heavy cuts, or, what amounts to the same thing, several lighter cuts simultaneously. Then again the provisions for feeding the tools to the cut are seldom as adequate as they should be, and hence it seems somewhat strange that the tail-spindle should be selected for this purpose at all, while the lathe carriage, which is better adapted, and is intended for this purpose, is allowed to stand idle. In general practice, though, the employment of box-tools is usually confined to "turret-lathes," and are used almost entirely on work of very small diameter, the subsequent operations (if any) on the work being performed by means of other tools held in the other sockets of the "turret-head." This is one of the principal advantages possessed by the "turret-lathe" over the ordinary lathe, but with tools properly designed and constructed it is very seldom but what the

work can be done equally as well on the ordinary lathe as on the "turret-lathe."

The most recent improvements in box-tools consist in the substitution of "circular cutters" for "plain cutters," the adaptation of the box (tool-holder) to the tool-rest of the lathe instead of fitting it on the tail-spindle or in the "turret-head," and in arranging the box in such a manner that other tools may be readily attached thereto, for completing the subsequent operations on the work when such are required, which is very clearly exemplified in the following engravings, Figures 218 to 221 (inclusive).

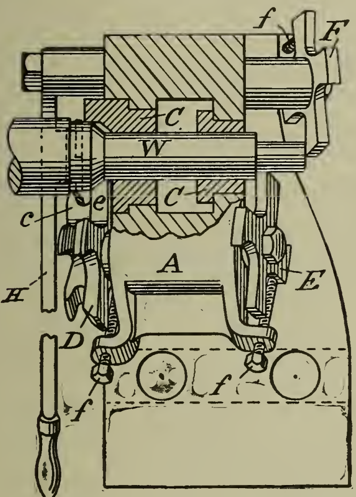


Fig. 218.

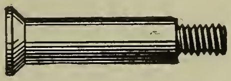


Fig. 217.

Figure 217 represents the work (which is what is termed a "countersunk-headed bolt") to be turned, threaded and cut off at three operations.

Figure 218 represents a plan view (partly in section), Figure 219 an end elevation, and Figure 220

a front view in perspective of the box-tool, with the cutters in position as the work is being turned.

In construction, the box is similar to the boxes for holding plain cutters of the ordinary type. The body A (similar reference letters denoting the same parts in all the figures) is made of cast iron and is fitted by means of a tongue a (shown in Figures 219 and 220) in the T slot of the tool-rest B B, in which it is held by the bolts b b b; the work W is steadied in the bushings C C. In turning the bolt, the first cut is started by the advance lip c of the cutter D, which re-

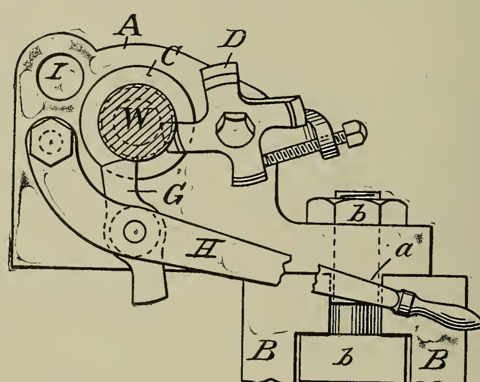


Fig. 219.

duces the work to the size of the outer diameter of the bolt head. The second lip e of the same cutter turns the body to size, and bevels the head to the angle required. The cutter E reduces the bolt on the end ready for threading, and also regulates the length of the body. The cutter F turns off the end, and determines the length of the threaded portion. The cutters are then backed-off from the work, and the end threaded by means of the die shown in Figure 221, the die-holder being located and held in the box by

means of the shanks G and H, the shank G fitting into the bushings C C, and the shank H into the socket I (Figure 219). In this case the bolt is threaded at a

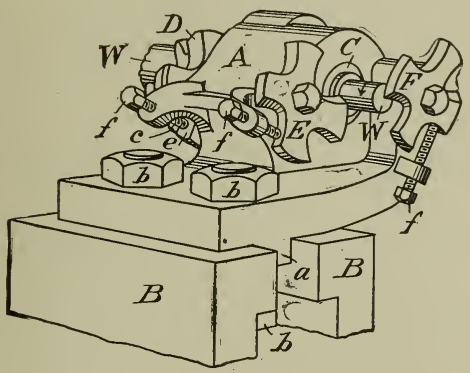


Fig. 220.

single cut, the lathe being reversed as the die reaches the shoulder of the work. The work is then cut off by means of the parting tool G (Figure 219)

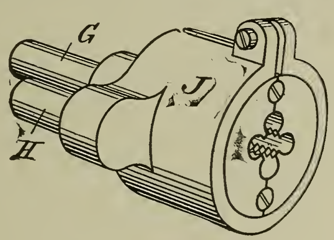


Fig. 221.

which is operated by the hand lever H. The cutters are adjusted (in the manner shown in Figure 215) by means of the adjusting screws f f f.

Essentially, in employing circular cutters in this manner, their diameters must be very exact, as the diameters of the cutters determine the diameters of the work, no adjustment of the cutters for this purpose being possible, as the pivot pins of the cutters are, practically speaking—fixtures. Obviously as the cutters become worn or dulled, the adjusting screw can be backed out of the way, and another tooth or point can be brought into position; and any or all of the teeth can be ground as much as desired on the radial surfaces without affecting the accuracy of the cutters or work in any way whatever.

If preferred, the parting tool G can be backed off or relieved in the ordinary way, but the circular cutters for turning, can only be relieved on the sides, if at all.

In practice the angles to which the cutters are inclined for clearance are precisely the same as when ordinary turning tools are employed, but in the engravings the clearance angles are somewhat exaggerated to show this feature of the construction more prominently, a remark which (as far as the exaggeration of angles is concerned) applies with equal force to many other illustrations throughout the entire work, reference to which is made here to avoid any misunderstanding.

CHAPTER XXX.

LATHE WORK.—*Continued.*

MEASURING INSTRUMENTS FOR LATHE WORK.

Fortunately for the machinist of the present day, the management of most machine shops realize the importance and imperative necessity of furnishing standard gauges for the workmen's use, and as a general rule make every reasonable effort to provide such instruments for their employees. But there is of course a limit by which the supply of such instruments has to be regulated, for when the length and diameter of the work exceed a certain figure, then the employment of standard gauges for general use in the workshop becomes an utter impossibility, unless such standards are made in the form of measuring bars with hardened ends, templates, inside micrometer calipers, etc., and even then it is best to do the measuring by the ordinary means, and to employ the standards as reference gauges, or to set the calipers, or test the work by. The standard gauges for either large or small work need not of necessity be made or provided in sets, but should always be such as are best adapted for the work. In fact a shop that is not provided with standards suited to the requirements of the men and work, is not considered to be in "touch" with the approved methods and practice of the day. Many of our leading mechanics prefer to furnish their own standard gauges, and either make them themselves or buy them separately (in such sizes as are

suited for their work), or in sets, as preferred. A set of such gauges, consisting of forty-five hardened discs, ranging in size (by sixteenths) from $\frac{1}{4}''$ to $3''$ inclusive, can, owing to the improved methods of manufacture, be bought for the small sum of $35. And it is certain that but very few shops or individual mechanics could make a set of such gauges for twice that figure. There is therefore very little inducement for either a mechanic or a shop to make their own gauges, unless they do so for specific reasons; but somehow or other, there are numbers of superintendents and mechanics who prefer to make their own gauges and other tools besides, whenever possible (regardless of the fact that it has in all probability cost them considerably more to make the gauges than they could have been bought for, and that they have in most cases got an inferior article at that), and seem to take a pride in showing and alluding to them as being of their own make.

These remarks must not be construed into implying that gauges (or other tools) should not in any case be self-made, when such can be purchased from the dealers, but, on the contrary, when the proper facilities and skill are available, we would advise that such implements and tools should be self-made, for we have in numerous instances seen examples of such self (home)-made tools that would compare very favorably with, and in some cases excel, anything of the kind on the market. But what we would assert is that, unless the skill and facilities are available, it is a waste of time and money to attempt to make such implements or tools, when a superior article can be purchased at a less cost elsewhere. But, on the other hand, the crudest kind of a gauge is preferable to none at all, even if it is only a cast-iron disc, plug or ring gauge. It can be preserved for reference and for setting the calipers, or testing the work by, and in that manner the correct size can be maintained for an almost

indefinite period, and the work and processes expediated considerably thereby.

PLUG AND DISC GAUGES.

In general practice "plug" and "disc" gauges are preferred and used more extensively on lathe work than any other kind (not excluding the regular and special forms of "snap gauges"). The plug or cylindrical gauges are frequently made in the form of "limit gauges," one end of the gauge being made a stipulated amount above and the other end below the size the gauge is intended to represent, so that, when a hole is bored to the gauge in such a manner that the small end of the gauge will enter freely, and the large end will not enter at all, the hole is known to be bored within the limits required. A more practical method of maintaining the size of the work within the limits desired has never been devised, and it cannot be too highly commended. The only objection to the employment of plug gauges is that there is never any provision made to admit of the exit of the entrapped air when the plug gauge is applied to test the size of a hole that is open on one end only, and hence it is impossible to tell with any degree of accuracy whether the hole is bored to the right size or not. So frequently has the necessity of some such provision being made in plug gauges for this purpose occurred under the author's observation and in his own practice, that he is convinced that the defect should be promptly remedied. There are two methods by which this can be done. The first and easiest (and which we have usually employed in our own practice) is to cut a small groove the whole length of the gauge, as shown in Figure 222, which represents a one-ended plug gauge, with the groove A cut therein. The second method is to drill a small hole through the body of the gauge, as shown (in the same figure) by the dotted lines at B, with an opening at C.

In boring such work as that shown in the semi-sectional view, Figure 223, where W represents the

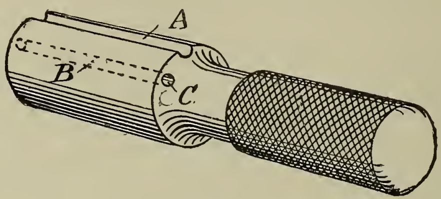


Fig. 222.

work bolted to the face-plate D, with the plug gauge E already entered therein, it will be apparent that, unless some provision for the purpose mentioned is made, the hole would have to be bored larger than required before the gauge could be entered at all.

Another form of gauge employed somewhat exten-

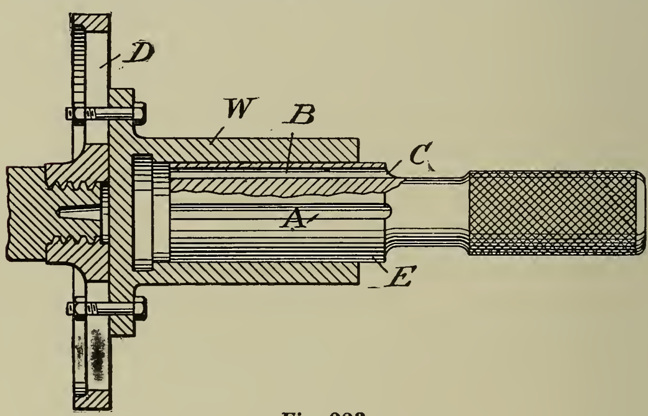


Fig. 223.

sively for boring holes is the disc gauge. These gauges are usually arranged in such manner as to be held by an inserted handle, as shown in Figure 224, which represents a disc gauge made by the Brown & Sharpe Mfg. Co. The disc shown in Figure 224 is held by the handle shown in Figure 225. These

gauges are exceedingly useful in the workshop, and are frequently used without the handles for setting calipers, testing measuring tools and determining sizes in shop practice. They are, however, owing to their

Fig. 224.

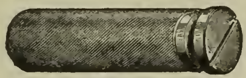


Fig. 225.

narrow width of surface, intended to serve more as reference than as working gauges, but when made sufficiently wide make excellent working gauges.

RING OR COLLAR GAUGES.

"Ring" or, as they are usually termed, "collar" gauges are employed either for turning or boring, or both, according to the manner in which they are constructed.

Figures 226 and 227 represent a special form of collar gauge that can be used for turning or boring, or both, as preferred. As shown therein, the inside of the ring is bored to 1″ standard size, and is used for turning shafts and other work of that diameter. The ring is also turned on the outside to 2″ standard, and is used for boring holes of that diameter. This form of gauge was originally intended to serve as a reference gauge only, was made of a good grade of very hard cast iron, and when simply used as such, it served its purpose admirably, as there was no wear whatever to it. It is now used as a working gauge, is made of steel, and is hardened and ground in the usual way. Other proportions for the inside and outside diameters can of course be employed if desired.

In boring ring or collar gauges that require to be very accurately sized, the work (ring) should never be held in a lathe chuck by its outer diameter, as the

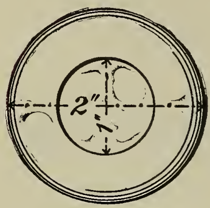


Fig. 226.

Fig. 227.

pressure required to hold it may cause it to collapse somewhat, and on the pressure being released the work would spring back to its original shape, and hence the hole would not be true. The work should

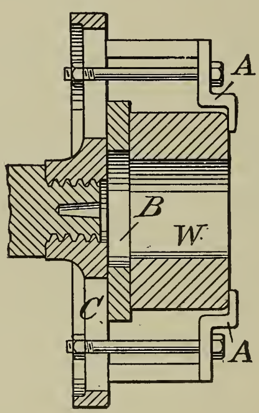


Fig. 228.

therefore be held in the manner shown in the semi-sectional engraving, Figure 228, where the work W is held by means of the clamps A A′ on the ring B against the face-plate C.

Another very handy form of collar gauge is shown in Figure 229. This gauge is bored to fit on the tail-center of the lathe, and has removable distance pieces or tram-points a a′ a″ a‴, which can be adjusted to represent the radius of any diameter to be turned on the lathe. It is used for facilitating the setting of lathe tools in the manner shown in Figure 230, where A represents the collar gauge in position on the dead-center o, the work W being held between the centers in the usual way.

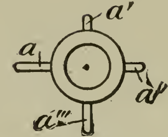


Fig. 229.

It is obvious that if the gauge is rotated, the tool can be adjusted thereby to the radius required by making the point of the tram a to just touch the point of the tool T in the manner shown. It is not claimed that this method is accurate enough to finish work by, for the lost motion in the cross-feed screw would prevent this; but it has been found of great assistance in setting the tools for roughing cuts.

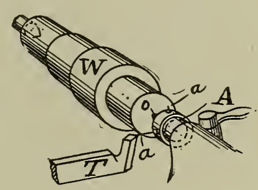


Fig. 230.

CHAPTER XXXI.

Items of Interest.

"ODD-LEGGED CALIPERS" AND THEIR USES.

Figure 231 represents a pair of "odd-legged calipers," which consist of a pair of caliper legs, with the toes both pointing in the same direction. This form of caliper is quite common in England, but they are not used to any extent in America. In fact, although we have been in a great many shops, we cannot recall a single instance where they were used, still we are informed on reliable authority that they are used here occasionally. But there is one thing of which we are certain, and that is, that, if their utility was better known, there are few machinists who would care to be without them. It is, therefore, intended to show a few

Fig. 231.

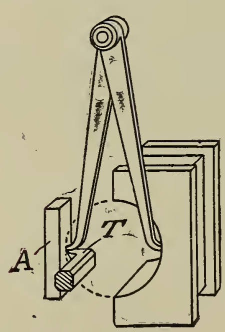


Fig. 232.

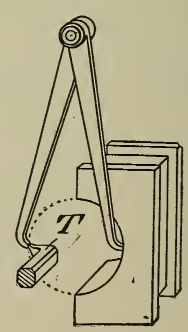


Fig. 233.

examples of their application in machine-shop practice.

Let it be supposed that a semicircular bearing has

to be bored, such, for instance, as the axle box for a locomotive engine or one of the brasses for a connecting-rod. When the work has been chucked and the cut started, the diameter of the bore would in ordinary practice be measured in the manner shown in Figure 232, by means of a pair of inside calipers and a small scale or parallel A held against the point of the tool T. In the hands of a careful workman the diameter of a semicircular bore can be measured very closely by this means, but this method is by no means as reliable as when the odd-legged calipers are employed for this purpose, as the measuring can be done direct from the point of the tool to the bore of the work in the manner shown in Figure 233. When used as shown in Figure 234, these calipers can be employed in such a manner as to simplify and ensure the more correct admeasurement of distances on many other kinds of machine and vise work. As, for instance, in measuring the distance from the end a to the shoulder a′ of the work W (Figure 234), usually the end a would be faced-off first, and the distance from a to a′ measured by means of a pair of inside calipers, holding a parallel against the face a to measure from. But obviously as shown in the figure, either surface can be faced first when the measurements are made by means of the odd-legged calipers. Or, in a similar manner, in measuring from the surface a′ to the surface a″, either surface can be faced-off first, as desired, if the measuring is done (as shown by the dotted lines) with these calipers.

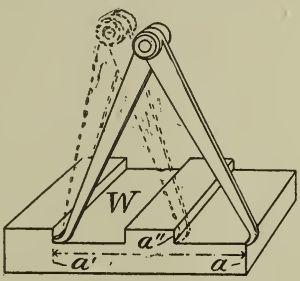


Fig. 234.

Reference has already been made * to the employment

* Chap. XXI., Fig. 161, page 201

of this form of caliper for the purpose of locating the holes in jigs, die-plates and other work requiring to be very accurately spaced.

By the ordinary methods the holes are always spaced off, and laid out in circles, regardless of the means to be employed for doing the boring. But, as explained in the chapter referred to, the necessity for laying the holes out in circles does not always exist; in fact, it sometimes happens that these circles lead to confusion, besides being a waste of time and marring the surface of the work. Then again the holes are usually first indicated and bored, and are then fitted with plugs to admit of the necessary measurements. This method of fitting plugs in the holes is very accurate and reliable, and is by no means to be condemned; but so long as it amounts to precisely the same thing as measuring from edge to edge of the holes themselves, it is somewhat surprising that the latter method is not more generally adopted, thereby saving the expense of fitting the plugs. There are at least three methods by which equally reliable results can be obtained with a fraction of the time and trouble. The first method consists in measuring from the outer edge (diameter) of one hole to the outer edge of the other hole by means of a pair of ordinary inside calipers, adding (if the holes are to be bored alike) one diameter to the distance the holes are to be spaced apart, or an equivalent amount when the holes are of different diameters; or, if preferred, measuring from the inside edge of one hole to the inside edge of the other hole, and, instead of adding, deducting the necessary amount from the distance the holes are to be spaced apart, making the measurements by means of either inside or outside calipers as desired. By the second method the measuring is done by means of the odd-legged calipers, measuring, as shown in Figure 235, from the outside a' of one hole to the inside a of the other hole.

This is the most accurate method of any for measuring the distance the holes should be spaced apart, because in measuring from the inside of one hole to the outside of the other hole amounts to the same thing as measuring from center to center of the holes. When the holes are both of the same diameter, the calipers should be set to the distance the holes are to be spaced apart; but when the holes are of different diameters, then the calipers should be set one-half of the difference in the two diameters less than the distance the holes are to be spaced apart. For example, let it be supposed that two holes are to be drilled in a piece of work, the diameter of one hole to be 2″, and of the other hole 1″, to be spaced 4″ from center to center; as one-half the difference in the diameter of the two holes is ½″, the calipers should be set to 3½″, instead of 4,″ the distance from center to center of the holes.

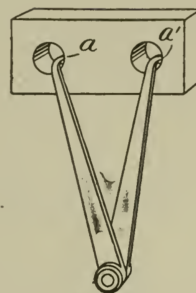


Fig. 235.

The third method consists in making the measurements in any of the foregoing ways, but by means of a pair of "beam" calipers. But if the measuring is to be done in the same manner as with the odd-legged calipers (as shown in Figure 235), the adjustable jaw should be reversed on the caliper beam, so that the inside measuring tongues will both face the same way.

For making measurements in this manner beam calipers have the advantage of being adjustable to the thousandths of an inch. But, after all, in the hands of a careful and skilled mechanic, there are no surer means by which comparison in measurements can be as accurately determined as by the "sense of touch."

Hence, many of our leading mechanics prefer the plain common riveted caliper to any other kind, depending on delicacy of touch alone to obtain the required precision in their measurements.

A very simple and efficient gauge is the test or measuring bar shown in Figure 236. These gauges

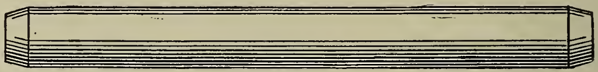


Fig. 236.

are made of any length desired, up to say 12″, are hardened and ground on the ends, to the shape shown in the figure. This form of gauge is very popular, and is easy to make. It is not, as far as we are aware, on the market, but it seems as though there would be a good demand for it, if it were on the market.

CHAPTER XXXII.

ITEMS OF INTEREST.—*Continued.*

FACE-PLATE PARALLELS.

Of the many little conveniences for facilitating the various operations on lathe work there is probably none that receives less attention than the distance pieces or parallels for blocking out the many kinds of work from the face-plate, and yet it is always desirable that a convenient form of parallel should be available at all times, for it is often a matter of some difficulty to hold the ordinary parallel (such as used on the planer or shaper) in place on the face-plate while the work is being set in position for the operation.

A very convenient form of distance piece or parallel is shown in Figure 237. This parallel can be very readily set on the face-plate in any position desired. It is held in place by means of a bolt inserted in the tapped hole a, and is slotted at b to admit of the clamp bolts being placed either on the inside or outside of the work. The parallel can be made to hold the work any distance from the face-plate required. It can be made from a separate pattern, or, when such are available, from the lugs of the piston ring casting (shown in Figures 141 and 142) after the rings have been cut off.

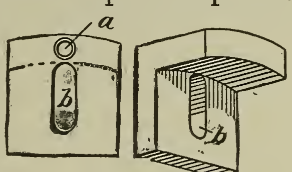


Fig. 237.

They are also very handy for facilitating the setting of a number of pieces of work, such as pulleys, gears, etc., either by the inside or outside diameter of the rim. When employed for setting the work by the outside diameter, they are stepped in the manner shown at a b, Figure 238, and when employed for

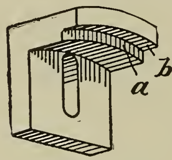


Fig. 238.

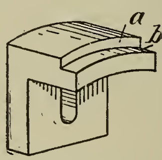


Fig. 239.

setting the work by the inner diameter of the rim, they are stepped as shown in Figure 239.

When arranged in this manner, after the parallels (three being the number usually employed) have been set for the first piece of the work, they are almost equivalent to a lathe chuck, as all that is required when one piece has been operated on is to remove that piece and insert another piece right in the same place. It will then be found that very little extra setting is required thereon.

MAKING SPRINGS IN THE LATHE.

There are many excellent devices for making helical (spiral) springs in the lathe, most of which are so familiar as to need no mention herein.

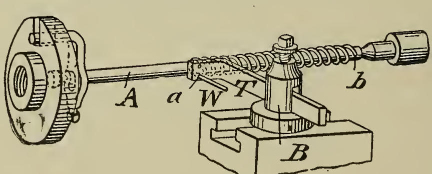


Fig. 240.

A very simple and efficient device for this purpose is shown in Figure 240. The device consists of a L

tool T held in the tool-post B with a hole drilled therein at a, to admit of the wire W being passed through it freely. The wire is fastened in the end b of the arbor A and is coiled by revolving the arbor in the ordinary way, feeding the wire and guide tool T along by means of the screw-cutting feed. By this means any number of coils or turns to the inch can be made as required; but as the spring will expand on being relieved, a smaller arbor should be used than the internal diameter of the finished spring.

FLUTING TAPS, ETC., IN THE LATHE.

In almost every machine shop there is an occasional call for some method or device suitable for "grooving" and "fluting" work of various kinds—such as taps, reamers, spindles for automatic feeding, "oil cups," etc.; and in many such cases, as no milling machine is available, the work is usually done on the planer or shaper, and afterwards finished by the vise-hand, or it is done altogether by the vise-hand.

There is no question but what the work can be done well by both the above methods by any ordinary mechanic, but as the grooving or fluting of such work as that mentioned can be done more expeditiously and to better advantage in the lathe, and as the outfit required is of a simple and inexpensive kind, it is of course better to do it on the lathe.

The operation of grooving or fluting work in the lathe can be performed in two ways: first, by means of a traversing tool held in the tool-post, and fed across the work by means of the screw or carriage feed, the work being held stationary between the lathe centers; and secondly, by means of a rotary cutter revolved between the lathe centers, the work being held between chucking centers, and the operation performed in precisely the same manner as if performed on the milling machine.

The first method is seldom resorted to except in the absence of any other machine on which the operation can be performed. But by the second method the operation can be performed with an efficiency and at a cost that will compare very favorably with the same operation on the milling machine.

The manner in which the operation is performed

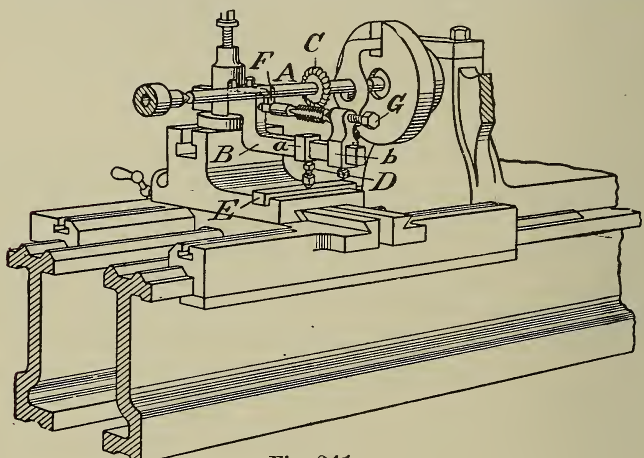


Fig. 241.

by the second method is shown in Figure 241, wherein the cutter C is held on the arbor A between the lathe centers, and the work (tap) is held between the chucking centers B. The shank of the chucking centers is held in the tool-post, which admits of their being adjusted for height the same as any other tool. The chucking centers and work are supported by means of the adjustable bracket a and supporting screw D, which is fitted on the bottom in a hole in the plate E to prevent the centers and work from moving sideways. The work is prevented from turning on the centers by the stop-plate F. The adjustable center G can be set to the length desired by sliding it along the bar B.

GRINDING.

In many lines of manufacture in modern machine-shop practice, grinding occupies a very important place. But in general practice it is not so much of a necessity, except on tool work, such as grinding reamers, etc. Yet there are very few places where grinding could not be profitably employed on certain lines of the work.

The term grinding as herein used is intended to imply the grinding and polishing of metal work by means of "emery" wheels, "corundum" wheels, "carbo-rundum" wheels, and belts and buff wheels charged with emery, crocus or rouge, but the term emery wheel or emery will be employed exclusively to designate any of the above compounds.

On this as on previous subjects it is assumed that the reader is already acquainted with, or can, from other sources, acquire a knowledge of the special forms of grinding machines. It may, however, be stated that a knowledge of the methods of operating the various forms of special and universal grinding machines is very desirable, and is not infrequently very important to the machinist.

GRINDING ON THE LATHE.

The devices for grinding work on the lathe are of such varied forms that to give them other than a passing notice would be almost a waste of time, as so much depends upon the nature of the work to be ground.

In ordinary practice it is usual to give the emery wheels a speed of from 3,000 to 5,000 circumferential feet per minute. This variation in the speed is dependent on the following conditions:.

First, by the grade of emery of which the wheel is composed; secondly, by the nature of the work, the amount of metal to be removed, and whether the work

has to be roughed out or finished; and thirdly, by the diameter of the wheel itself, and the power available for driving it.

The rate at which an emery wheel should be run is usually marked on a label on every wheel that is sent out by the dealer. But whenever there is any doubt as to the speed at which an emery wheel should be run for any kind of work, the question is generally referred to the manufacturer of the emery wheels, stating the kind of work to be ground and all other particulars. And it might be as well to state here that a great deal of annoyance and expense can frequently be entirely avoided, and much more economical and satisfactory results obtained by following this method of procedure.

For grinding work on the lathe two methods are in vogue for furnishing the power to drive the emery wheel. By the first and most efficient method, the power is supplied independently from an overhead drum, and by the second method the power is supplied either directly or indirectly from the lathe itself.

Regarding the employment of the first method of furnishing the power, whenever there is a sufficiency of such work to be done to warrant the cost of construction, it is much to be preferred to any other, inasmuch as the motion is furnished direct to the wheel; and when not employed for grinding the drum can be utilized for other purposes besides—such, for instance, as driving a drilling or other attachment.

But by the second method, wherein the motion for driving the grinding wheel is derived from the lathe itself, the grinding cut must of necessity be very light, as the appliances which are driven in this manner are always intended for light finishing, and never for roughing out work.

Sometimes the device is driven from the face-plate, and in other cases from the cone pulleys of the lathe.

When the motion is derived, as explained, from an overhead drum, the grinder usually partakes of the form shown in Figure 242, wherein the grinder A is represented as being held in the rest B B in place of the tool-post, the motion being supplied direct from the drum by means of the belt C C.

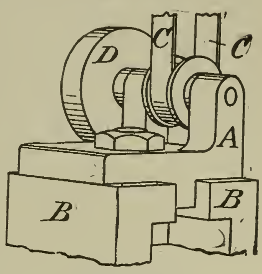


Fig. 242.

This form of grinder is mostly used for grinding cylindrical work, the work revolving slowly (in either direction as preferred) between the lathe centers. It is, however, occasionally used for grinding (sharpening) reamers and such work, in which case the work is fixed between the centers but not revolved.

When it is employed for grinding internal cylindrical surfaces, the wheel D is removed and a smaller chucking arbor fixed on the end of the spindle in the place thereof.

There are other special forms of grinders for the lathe, but the above is what may be termed the regulation style.

Figure 243 represents a universal grinding attachment for lathes. It consists of a grinding wheel A mounted on a compound slide rest, and two brackets B B′ which are clamped on the shears of the lathe bed. A glance at the engraving will at once show the arrangement of the pulleys and belts. The flat belt C receives its motion from the cone pulley of the lathe and thence transmits the motion to the grinding wheel by means of the round belt D which runs in grooved pulleys.

The bracket B is clamped on the shears opposite the largest step of the cone pulleys, and can be adjusted vertically to correspond with the height of the

lathe-spindle, and horizontally to give the required tension to the flat belt, which arrangement makes it possible to use the same belt on nearly all sizes of lathes.

The bracket B′ is also clamped on the shears, but to the right of the tail-stock. The pulley shown thereon serves to guide and also to give the required tension to the round belt that drives the grinding wheel. A constant tension is maintained on the belt by means of a spring inclosed in the box E between the clamps and the pulley.

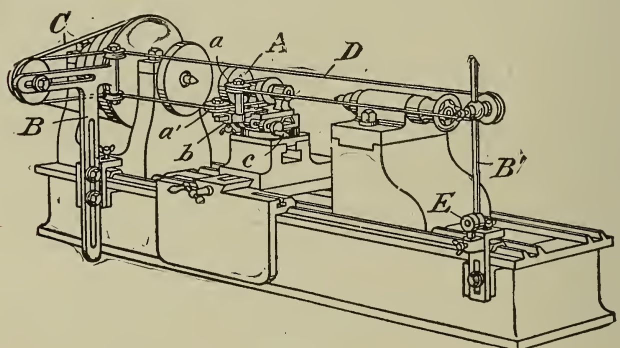


Fig. 243.

The clamps B B′ are adjustable to suit every design and thickness of shears. The guide pulleys a a′ are adjustable horizontally by means of a slide bar and a small bracket b, to bring them in line with the guide pulleys on the brackets B B′, and will generally come in line with the lathe-shears. The slide rest upon which the grinding wheel is mounted is made to swing round to any angle desired, the same as a compound rest, whenever it is required to grind the lathe centers, taper holes, etc., the hand wheel c being used for the feed.

It is often desirable when grinding work on the lathe to employ grinding wheels which differ in size

and shape from the ordinary forms and sizes ; and in other cases it is frequently necessary to fix the wheel on the chucking arbor by other means than those usually adopted for this purpose, which generally consists in holding the wheel on the arbor or spindle between two collars by means of a jam-nut or its equivalent in the form of a binding screw. Especially is this necessity felt when grinding the internal surfaces of work, as the chucking screw or nut would be in the way, owing to the contracted position in which the wheel has to work.

As most of the grinding wheels of small diameter can be softened by the application of heat, they can very readily be secured on the end of the arbor or spindle by simply heating the latter by means of a bunsen-burner, and then screwing or pressing the wheel thereon as far as required; when, on the spindle being cooled off, the wheel will be found to adhere with surprising tenacity ; or, in a similar manner, the wheel can be fastened on the spindle by means of a little gum shellac.

So firmly can an emery wheel be held by the above means that it can be used until it is worn right down to the spindle—or splits before it becomes loose.

Small grinding wheels can be made or shaped to any form desired, either in a mold, or by heating the compound on the spindle with a bunsen-burner until it can be manipulated to the shape required, using for this purpose the parts of other (larger) wheels which have been previously discarded on account of wear. In this manner a good deal of time and expense can frequently be saved, besides utilizing the scraps of larger wheels which would otherwise have to be thrown away. It is perfectly safe and proper to employ the scraps of larger wheels to make smaller wheels of, as there is no danger of the smaller wheels bursting. And, although larger wheels could in like manner be

constructed out of scraps, we should hardly think it safe to employ the wheels so made for practical purposes, for, though a large wheel made in this manner might to all appearance be perfectly sound, there may be some hidden flaw which could not be detected until the wheel burst. We have never seen wheels made, or attempted to make wheels in this manner that were over three inches in diameter.

CHAPTER XXXIII.

Items of Interest.—*Continued.*

GRINDING PLANE SURFACES.

The grinding of plane, parallel or flat surfaces is very easy of accomplishment, providing the facilities for doing the work are of the right kind. There may be some difference of opinion as to what constitutes the proper facilities for grinding any kind of work, but the principal object is to grind the work perfectly true with the least expenditure of time and money, and the ability to accomplish this is of more importance than anything else. Hence no particular method or system can be advocated for grinding flat surfaces, in preference to others, unless it can be proven that one method will give better results than another, which is at all times a matter of some difficulty; for when once any particular method has been decided upon for doing the work it is generally retained unless it can be shown that better results are being obtained on the same class of work elsewhere by some other method.

One of the principal reasons and advantages of finishing parallel surfaces by grinding is the avoidance of having to finish the work while it is held in clamping fixtures of any kind, which are at all times objectionable, inasmuch as there is always a likelihood of the work being sprung when it is so held; and for that reason, though it may be absolutely necessary to hold the work in a chuck or by clamps while it is being roughed out, it should always be finished in such

manner as to eliminate all inaccuracies which may have been caused by clamping; and this can only be accomplished by traversing the work under, over or by the grinding wheel without there being any strain upon it from any cause whatever. One of the most practical methods of surfacing work by grinding is to arrange a perfectly true work-table over the grinding wheel in such manner that the grinding wheel can work freely in an aperture in the table exactly level with the upper surface of the same, so that by sliding the work on the table directly over the wheel it can be ground true without being held by chucking or clamping.

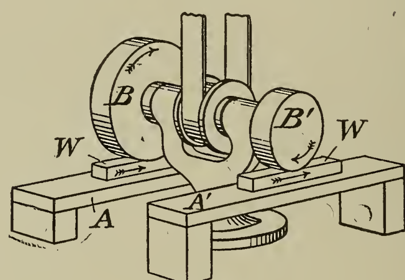


Fig. 244.

Another method regarded very highly everywhere is that of sliding the work on a similar work-table arranged under the grinding wheel, the principle involved in the construction and operation of the machine being the same as shown in Figure 244, where A A′ represents the (in this case improvised) work-table, B B′ grinding wheels, W W work.

It is very rarely that a true surface can be ground when the grinding wheel is run at such a high rate of speed as five thousand circumferential feet per minute.

Such a speed is all right when the object sought is principally to remove stock and obtain a reasonably

true surface on the work; but where it is desired to produce a perfectly true surface the speed of the grinding wheel must be reduced (for finishing) until there is no perceptible or actual vibration to the wheel at all, or, in other words, until the wheel will run absolutely smooth.

It is often possible to produce a much truer surface with a coarse grade wheel running with a perfectly smooth motion than can be produced by a finer grade wheel running at a higher velocity, as a wheel running under the latter conditions has usually such an undulating motion that it is impossible to produce a true surface; hence a finer grade wheel running with a perfectly smooth motion will produce a smoother, and, if such a thing is possible, a truer surface than a coarser grade wheel running under the same conditions.

The undesirable effects of high velocity grinding can to some extent be minimized on the same grinder by employing a coarse grade wheel of large diameter (speeded at the regulation rate) on one end of the arbor of the machine for roughing the work out, and a finer grade wheel of smaller diameter on the other end of the arbor to finish the work by (as shown in Figure 244). But, although the placing of a wheel of smaller diameter on the same arbor is a ready means of reducing the circumferential velocity of the grinding wheel, yet, practically speaking, the undulatory motion of the belt and grinding wheels still remains to be overcome, and this can, as already stated, only be accomplished by reducing the speed until the wheels have a perfectly smooth motion. The amount of this reduction of speed will depend to some extent on the general condition and construction of the machine, and consequently, if the machine is of a good design and in good condition, a very slight reduction in speed may accomplish the desired result; but if the

machine is faulty, or out of order, a considerable reduction in speed may be necessary.

Usually a perfectly true surface cannot be produced on the best machines at a greater speed than two thousand circumferential feet per minute, but this of course is only for finishing. A speed of nearly or fully five thousand feet per minute can be maintained at all times for roughing out, a very slight allowance, not exceeding the one-thousandth part of an inch, being amply sufficient for finishing, and consequently the finishing can be accomplished even at a greatly reduced speed—very expeditiously.

The method of surface grinding shown in Figure 244 is employed quite extensively in general practice where the amount of the work to be ground is insufficient to call for special machines for the purpose. In this case an ordinary bench grinder is employed with an improvised work-table A and A′ arranged under the grinding wheels in such manner that by raising or lowering either or both ends of the work-table the work can be fed under the wheel (in the direction indicated by the arrows) and ground to the size required.

For occasional jobs of grinding this method can be employed on almost any ordinary grinder, and is in lieu of better facilities as efficient as anything which can be improvised for the purpose.

In Figure 245 is shown a device employed for facet grinding, and also for grinding small pieces of very thin work, such as the cutters for "horse" and "barber's" clippers, etc.

The disc A, which is usually made of lead or cast iron (though occasionally faced with solid emery), is arranged horizontally on the top of a vertical spindle B, and is driven from the pulleys D by means of the bevel-gears C, and in other cases by means of a quarter-turn belt. In grinding with this device, the

disc A is moistened or lubricated with water or oil and then sprinkled plentifully with emery. The work is ground by holding it thereon by suitable means, the roughing out being done near the outer circumference of the disc, and the finishing by holding the work near or directly over the center, which, as in the preceding example, amounts to the same thing as roughing out at a higher and finishing at a lower velocity of speed.

A very efficient and practical method of grinding parallel work is shown in Figure 246. It consists in

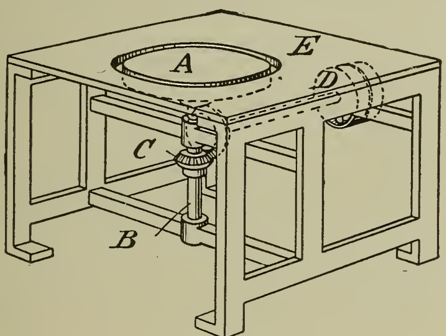


Fig. 245.

arranging a sliding grinder-head on the cross-rail of a planer in such a manner that the grinding wheel can be driven from overhead in the ordinary way, and at the same time a reciprocating lateral motion is imparted to the sliding head so as to cause the grinding wheel to cross and re-cross the work, thereby maintaining a true surface on both the wheel and the work.

In the figure A represents the sliding grinder-head mounted in the slide-way A′ on the cross-rail B. The grinding wheel C is driven by the belt D D. The reciprocating motion is imparted to the grinder A C from the crank E and connecting-rod F.

The work is held in a suitable manner on the platen (the speed of which is reduced to correspond with the requirements) of the machine. If any of the bolt and slot holes extend through the platen, they are plugged up with wood to protect the mechanism underneath from the emery dust. The V-ways are protected by having a roll of cotton-muslin on a drum on each end of the bed; one end of the sheet muslin is attached to the end of the platen, so that, as it is traversed backwards and forwards, the muslin is wound or unwound on or from the drums according to the direction in which the platen is moving, the motion of the platen causing the muslin to unwind from the

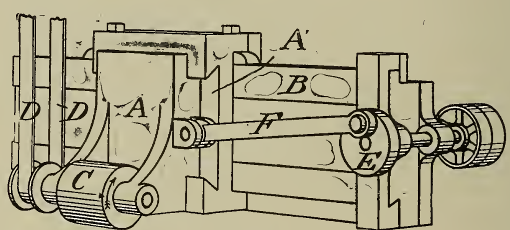


Fig. 246.

drum and to raise a weight attached thereto, which, on the platen being reversed, rewinds the muslin on the drum.

Grinding machines constructed on these lines are used for grinding hardened guide-bars, and the bodies of connecting-rods, and a large variety of similar work, and are very successful and economical. On all such machines the grinder-head is operated directly on the cross-rail, but that shown in the engraving is a modification of the same device as adapted to and employed on the ordinary planer, the independent slide-way A′ being used in preference to the cross-rail to avoid wear on the latter.

The principle of giving a reciprocating lateral to

the grinding wheel has also been effected directly on the spindle of the grinder by means of a cam and a fixed roller, but the device shown appears to give steadier and more satisfactory results.

There are two very effective methods of grinding the edges of thin work. By "thin work" is meant either long or short strips or pieces of metal work, that is, say, from one-half inch to twenty feet in length, and of any width up to three inches, and from one-sixty-fourth to one-fourth of an inch thick.

By the first method (which is the one usually employed) the work is held flat-wise on the work-table or platen of the machine, and is fed by the side of a "dished" or "hollow" grinding wheel, so that the surface ground is perfectly straight, and not concave, as it would be if fed in a similar manner by the periphery of the wheel.

By the second method, after the work has been ground on the flat sides, a number of the pieces are bunched and clamped together, and the combined edges ground as though it were one broad surface, on any ordinary surfacing machine (such as already shown).

On many kinds of work a perfectly straight edge is absolutely necessary, and it is also essential that the work should be parallel and of the same width throughout its entire length.

On other classes of work, such as the knives for paper-cutting machines, dovetailed slide-pieces, etc., the edges of the work have to be beveled, and ground perfectly straight besides. By using ordinary care any of the above requirements can be fulfilled by either of the methods referred to, but, when the work has to be beveled on the edges, one piece only can be operated on at a time.

The manner in which the work is ground on the edges by the first process is shown in Figures

247 and 248, which represent an end elevation and plan view of the work-table or platen A, recessed grinding wheel and pulleys B, with the work W in position for the operation on the adjustable angle-plates C C C. The work W is a knife for a paper-cutting machine, and is shown separately in Figure 249.

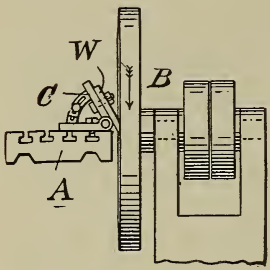


Fig. 247.

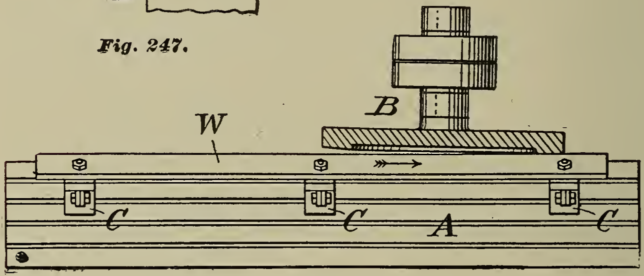


Fig. 248.

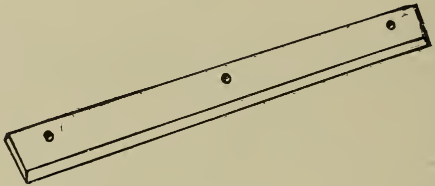


Fig. 249.

When the edges of the work have to be ground at right angles to the flat surfaces, it is only necessary to clamp the work directly on the platen and feed it along in the ordinary way, regulating the width (when such regulation is necessary) by placing suitable distance pieces in the T slots, and setting the work so that one edge abuts against them.

LEAD LAPS.

On lathe work journals and other kinds of work can be ground very truly by means of a common "Lead Lap," consisting of two bent straps (resembling a pair of ordinary "driving clamps") lined with lead, and adjustable by means of the binding screws, bored out a trifle longer than the diameter of the work and then charged with emery and oil.

This device, though old, is very efficient and is employed for finishing work to the exact size, after it has been machined or filed to a close approximation of the same.

A very true bearing can be made in this manner, and the only objection to its more extensive employment is that, though the work can be ground perfectly true at every point of its diameter by this means, it may not be equally true with its axis; hence the employment of other devices, by means of which the work can be ground while it is revolving on centers true with its axis; but in lieu of better facilities a good "lead lap" is by no means to be despised when a true finish is required.

CHAPTER XXXIV.

Items of Interest.—*Continued.*

POLISHING—BY GRINDING.

Another important branch of grinding (though not generally designated as such) is the successive grinding of work to a finished (polished) surface by means of "grindstones," "emery" and "corundum" wheels, emery belts, and buff or other polishing wheels, the requirements on this class of work being to obtain a high polish on the surface of the work without changing the shape thereof, or reducing the size more than necessary to accomplish the object sought.

Perhaps the most extensive means employed in machine shops, in roughing out the work under consideration, is the use of solid emery wheels; but, although the solid emery wheel is and can be used to good advantage in cutting down and shaping work in the rough prior to its being finished, the same end could undoubtedly be secured more expeditiously and to better advantage in many cases when properly handled on the grindstone, providing the latter is kept at all times perfectly true. This is fully evidenced by the very extensive manner in which grindstones are employed in preference to the solid emery wheel in the leading "cutlery," "Spring," and other manufactories.

When the work has been roughed out it is usually polished on a wooden polishing wheel of large diameter faced with leather, and charged with emery or corundum, and is constructed in the following manner: The wheel proper is first constructed, or built up

in the same manner as any solid wooden-pulley or drum; it is then turned up true, balanced, and faced on the periphery, with leather, the leather being stretched taut as possible, and held by glue and wooden pegs (such as shoe-makers use). The leather face of the wheel is then trued up and roughened by means of a coarse cut file. It is then coated with glue and charged, by rolling the wheel (while the glue is still soft) in a long narrow box or trough in which has been evenly spread a quantity of heated emery of the required grade. It is claimed that, "when the emery is heated before it is applied to the wheel, a perceptible gain is secured in the lasting qualities, as the emery is more thoroughly incorporated with the glue, and is consequently less liable to peel off in spots, or lose its cutting qualities so rapidly." (F. H. Treacy, "American Machinist," Vol. 14, No. 5.)

Round or flat emery belts are charged with emery in a manner similar to the above, the joint of the belt being made by chamfering the ends of the belt off, so that when it is placed together the jointed part is of the same thickness as the rest of the belt. The joint is made by gluing the parts together between clamps, the same as in making joints in wood, on pattern work, no lacing whatever being used; but as an additional security a few of the wooden pegs mentioned above are driven into the jointed parts in any place desired.

(We herewith make a digression to state that on quarter-turn and other belts employed for driving machinery for any purpose whatever, where trouble is experienced by the lacing, if the belt is joined in the above manner no further trouble will be experienced, as such a joint when properly made will generally last as long as the belt.)

The finishing wheels are made by placing together a number of soft "leather," "felt," "cotton flannel"

or "ducking" discs on the arbor of the polishing machine, revolving the wheels at a very high rate of speed, occasionally holding a cake composed of flour emery or crocus (stirred or mixed with bee's wax while in a melted state) and bee's wax against the periphery of the wheel while it is revolving in order that the discs may become coated or charged with the emery or crocus.

Much of the success of polishing depends on the state in which the polishing wheels and belts are kept. If they are allowed to get out of order the results may be very disappointing, and the blame is liable to be placed elsewhere than where it belongs. Hence, the wheels and belts should be kept fully charged, and true at all times, and careless handling of either the work or tools (for the wheels and appliances are tools in the same sense that other appliances and machines are) should never be indulged in or tolerated.

CHAPTER XXXV.

Drilling.

As the subject of drilling is so thoroughly understood, a very brief mention will suffice therefor. Hence we can only find space for a few useful hints which have proved helpful in our own practice.

Of recent years twist-drills have been employed for drilling holes up to three inches in diameter, almost to the exclusion of any other forms. In the larger establishments the drills are always ground or sharpened by the tool-maker in the tool-room on a special grinding machine, and, therefore, the operator or drill hand has nothing whatever to do but insert the drill in his machine and go ahead with his work, seldom knowing (and often not caring) whether the drill is operating under the most favorable conditions or not.

It appears to the author that there is need of, and a chance for, some improvement in this method. If a machine is to be operated intelligently, the operator, however humble his occupation, should be thoroughly versed in every detail of his work, and should know the "why and wherefore" of every detail in the construction of the tool he has to operate. If it is a "twist-drill" he should know that the diameter of the drill gradually diminishes towards the shank end, that it is relieved or "backed off" for clearance from the advance lip towards the next flute or groove, and the exact amount of clearance that should be given the cutting edge or lip in order to obtain the best results. He should also be able to grind the drill correctly either on the machine or by hand, and how to tell

when it is working properly. Then, even though he may never have to apply this knowledge, he can perform his duties in a more intelligent manner, and will in all probability take a deeper interest in what he is doing.

It is doubtful if there is any machine in use that will hold and grind a twist-drill as accurately as it can be ground by hand. A twist-drill can be ground so accurately by hand that, though its cutting action is perfect, the imperceptible heat generated by forcing the drill to the cut will expand the work slightly but sufficiently to prevent the drill being entered into the hole when the work has cooled off. In general practice, though, this degree of accuracy is seldom called for. There is one thing in favor of a hand-ground drill, which is that the clearance angles can be ground off straight—and a drill so ground seems to last longer and cut better than when backed off in the form of an arc, as with the machine-ground drills.

Another common mistake when the drills are machine-ground is to give the drills for all classes of work the same amount of clearance, regardless of the material to be drilled. This is seldom done through ignorance, but mostly through carelessness on the part of the attendant in the tool-room in not making the necessary inquiries as to what the drill is to be used for, and grinding a drill suitable for that purpose. If a reamer is called for, the inquiry as to what it is to be used for would almost invariably be made, and a reamer specially adapted for the material to be reamed is handed out. If this were more often done with reference to drills, the operator would not be so frequently working at a disadvantage as he now is, neither would there be so many broken drills.

Wherever a hole has to be drilled, there is nearly always another hole to be drilled in a counter location on some other part of the work, so that when the parts

are assembled together the holes will coincide. If the number of pieces to be drilled will warrant the cost, the work is "jigged," so as to save the time which would be occupied in laying out and setting the work, and starting the drill correctly.

When the quantity of the pieces to be drilled is below the minimum where the cost of jigging can be considered, there are three methods by which the holes can be correctly located.

The first method, which is the more often employed, is to lay out each part of the work separately.

The second method is to lay out and drill one piece of the work, and then use that as a template to mark off the rest of the work—or as a jig to drill it by. A good deal of time and labor can be saved and a degree of accuracy attained that is surprising by employing one piece of the work as a jig to drill other parts by, as, for instance, in drilling one or more cylinders and cylinder-heads that are not jigged, one cylinder-head can be laid out and drilled, and then used to drill the cylinder or the rest of the cylinders by; and in many cases it can be used for drilling the rest of the cylinder-heads also. And in a similar manner, as on stationary engine work, where the back cylinder-head is interposed between the engine-bed and the cylinder, the cylinder-head can be laid out first and drilled, and then used as a jig for drilling both the cylinder and the engine-bed. A large variety of work can be drilled in this manner, in most cases much closer than when the work is laid out separately, and with a fraction of the trouble.

The third method of locating the holes consists in making a template that can be used for laying out either or both parts of the work.

When work is "jigged" at all, a separate jig is generally made for each part of the work, the jig having flanges, lugs, or depressions thereon or therein, by

which it can be located on or within the work; or, *vice versa*, by which the work can be located on or within the jig.

Figure 250 shows the method ordinarily employed for jigging work of almost any kind. In the figure the work A, which represents a flanged pipe, is drilled through the jig B, the holes being located and the drill guided by the bushings a b.

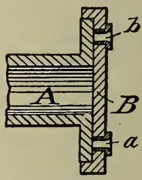


Fig. 250.

It is obvious that, if for any reason the holes in the flange are unevenly spaced, a jig constructed in this manner could not be used for drilling the flange of the adjoining piece of piping. An example of this kind is shown in Figure 251, where it is required to drill the flanges A A′, which abut against the angular metallic walls B′ B″. This example is taken from actual practice, and serves to show how a jig can be made so as to be used for drilling two separate pieces of work, and also, how a template made on similar lines can be used for laying the same off. Referring to Figures 252 and 253, which represent a plan view and side

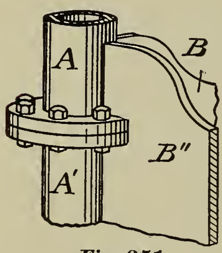


Fig. 251.

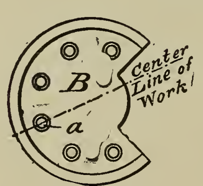


Fig. 252.

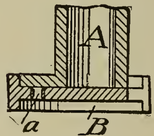


Fig. 253.

elevation (partly in section) of the jig B with the part A (Figure 251) in position to be drilled, it will be

seen that, if instead of recessing the jig plate B on one side only (as in Figure 250) it is recessed on both sides, it can be applied to the flange of either part of the work, and the holes correctly located and drilled through the same guide bushings; but when a jig is to be employed in this manner, the guide bushings a are made as shown (on an enlarged scale) in Figure 254, which admits of the jig being laid in close contact with the work, and of the drill being entered from either side of the jig as required.

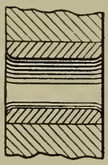


Fig. 254.

In the above case the jig is termed an "outside jig"; but when the nature of the work calls for it a jig can be constructed that will serve as both an "inside" and an "outside" jig; and likewise, when applied on the same principle to templates, they can be used for both purposes.

To demonstrate the above a somewhat exceptional example has been chosen, but it is doubtful if anything more appropriate could have been selected for the purpose.

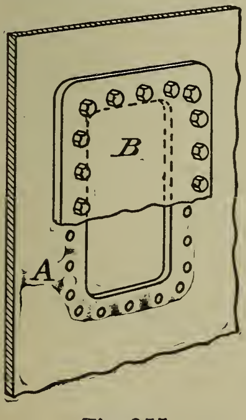
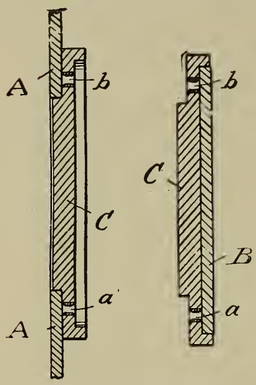


Fig. 255.

Let it be supposed that the plate A and cover B (which has been broken away to show the requirements), Figure 255, are to be jigged, and it is desired that the jig shall be arranged so that the plate A and the cover B can be drilled therewith. By arranging the jig in the manner shown in the sectional side elevations, Figures 256 and 257, it can be used for drilling each part as though it were made specially for that part.

In Figure 256 A A represents the work (plate) and C the jig inserted therein ready for the operation, a b representing the guide bushings which are the same as those shown in Figure 254. In Figure 257 the work (cover) B is shown in position ready to be drilled.



Figs. 256 and 257.

The compounding of drilling jigs can be almost universally applied with a certainty of success. But the system should not be carried to an extreme where real economy ceases to exist; or, in other words, it may not infrequently be more economical and advantageous to jig the parts separately. Still, as shown by the foregoing examples, whenever it is possible at a slight additional expense to construct the jigs so that they can be utilized for drilling both parts of the work, greater economy and accuracy can be readily secured thereby.

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